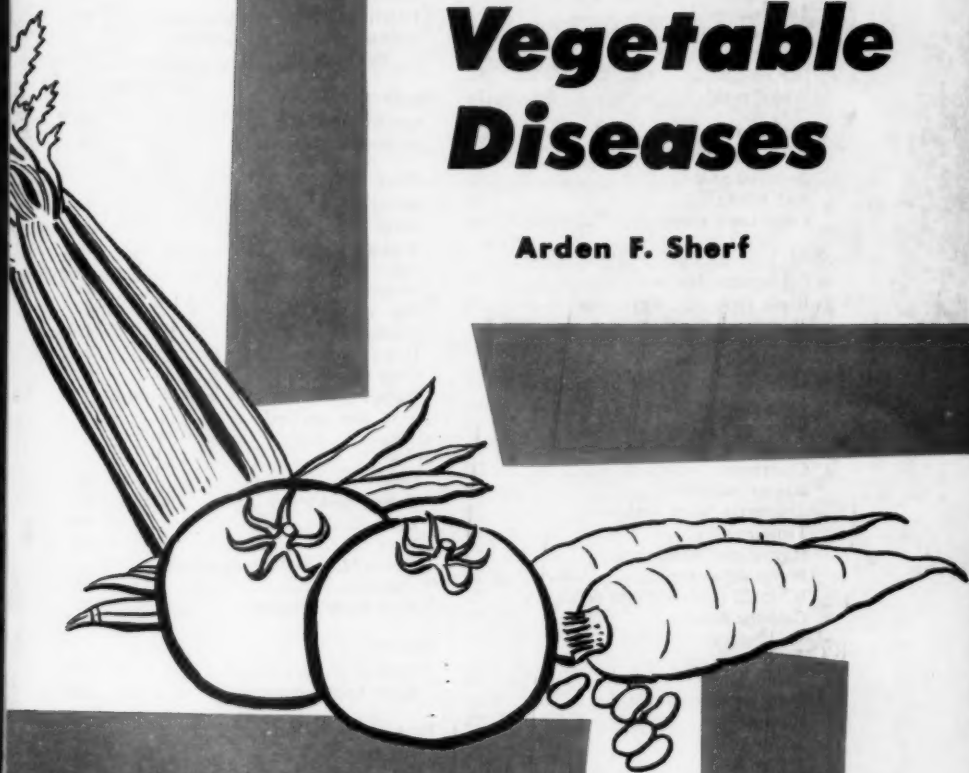


Vegetable Diseases

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VEGETABLE DISEASES

The production of high quality vegetables is big business in New York State. Approximately 184,720 acres are devoted to these crops. The products of 96,220 acres are for canning or freezing. The products of the remaining 88,500 acres go to fresh markets within New York or adjacent states. Most of the 28 species of vegetables commonly grown are subject to several diseases that will reduce yield and quality if uncontrolled. To remain competitive and successful, today's vegetable farmer must learn to cope with these diseases.

This bulletin describes only the most prevalent and damaging vegetable diseases and suggests the most economical and practical measures for controlling them.

Basic Information on Plant Diseases

For a vegetable to become truly diseased, several conditions must be present: a susceptible host plant, a pathogenic organism, a good method of distributing this organism, the proper environment for it to exist, enter the plant, and thrive. When all phases are satisfactory, infection may occur and a disease become established.

Causes of disease

There are four general types of organisms capable of causing vegetable diseases:

Fungi are tiny-celled nongreen plants or molds that reproduce abundantly by spores that are generally windborne. The spores germinate and enter the plant through wounds, natural openings, or directly into the outer layers to cause infection. Fungi are the most important cause of vegetable diseases.

Bacteria are microscopic single-celled organisms that reproduce by dividing into two parts. They gain entrance through wounds, through natural openings, by insect feeding, or by cultivation damage. Once inside the plant, bacteria multiply very rapidly, destroying the plant cells, plugging the plant water vessels, or killing leaf tissues.

Viruses are infective protein substances invisible even under ordinary microscopes. They rely on man or insects for dissemination. Viruses cannot penetrate directly but must be placed into a wound, broken leaf hair, or injected by insects. Common virus symptoms are mosaics, leaf roll, stunting, and ring spotting. Virus diseases are probably the most difficult to control.

Nematodes are microscopic eelworms frequently present in soil in large numbers. They obtain nourishment from host plant roots where they may enter and live (root knot) or they may remain outside the root but still feed on it. Nematodes rob the plant of food and reduce yield and quality.

Water is necessary for their movement through the soil. Nematodes are an increasing problem in muck soils and in upland mineral soils where highly susceptible crops are constantly grown.

Distribution of agent

There are many methods by which diseases can be transmitted including wind, blowing rain, and insects. Man also disseminates pathogens by tools, by handling or picking, and by transporting living plant parts such as seeds, tubers, and transplants.

Proper environment

Temperature of the air and soil, soil moisture, rainfall, and relative humidity are all very important influences on both the host and the parasite. Certain conditions are necessary for infection, others for development inside the host, and still others for reproduction of the disease organism and subsequent release and spread of its seeds or spores. This is the reason diseases fluctuate in importance from year to year.

Proper host

Most diseases are fairly specific in their choice of host, selecting by families, species, or even by varieties. This is probably the result of the genetic make-up of both the host and the parasite. The former can be changed by the plant breeder. The latter frequently is changed by nature and is exhibited as a new pathogenic race with increased ability to attack previously resistant varieties.

Methods of Disease Control

The choice of a proper control must be based on accurate knowledge of the disease, of its life cycle, and the time of infection, as well as the part of the plant involved, the method of agent distribution, and certain economic considerations. Useful methods include: (1) use of resistant varieties, (2) use of non-infested soil or long rotations, (3) complete or partial soil sterilization with steam or chemicals, (4) use of clean seed, either certified or grown in disease-free areas, (5) seed treatment with heat or chemicals, (6) control of insects and weed hosts, and (7) proper use of fungicides. In the following pages one or more of these controls is recommended as being most practical for preventing or reducing losses from each of the important vegetable diseases.

Proper Fungicide Usage

If chemicals are not used in a proper manner, they are useless and costly and possibly even harmful. What does proper usage involve? It involves using the right chemical in the right amount at the right time, and in obtaining the right coverage. Much research and extension time and thousands of dollars go into developing and testing effective, safe fungi-

cides. Many of these chemicals are for specific diseases on specific crops. If the right chemical is not used against a particular disease, poor results will be obtained.

In recent years new fungicides have become more and more specific, and the need to know which fungicide to use has increased. Our new fungicides are potent and often useful in small quantities. To use less than the recommended amount lowers the disease-controlling efficiency. To use more is costly and may entail dangerous residue problems on the edible portions of the vegetable. Therefore, use of the right amount is of paramount importance.

Proper timing of applications increases fungicidal effectiveness and also saves money. Certain diseases do not appear until a crop has made considerable early growth; thus early protection is not needed. In other cases diseases appear early and need controlling at that time, but not later. Some fungus organisms can cause infections only when plant parts are wet; consequently, chemical protection must be on the plants before wetting periods and not delayed until later.

Good chemical coverage is the final facet of proper fungicide usage. We recognize that plants are dynamic growing entities producing new foliage rapidly. Since fungicides in use today are surface-acting materials, new foliage, stems, and fruits need chemical coverage as they develop. Other reasons why repeated or replacement sprays are necessary include: washing and dilution from rain and dew, incomplete initial coverage, and chemical or weathering breakdown on constituents. Careful adjustment of spray nozzles, speed of tractor, and gallonage per acre, and the use of sticking or wetting agents are other important considerations.

ASPARAGUS

Rust

Rust (*Puccinia asparagi*) may be present occasionally. The bushy tops of the plants become covered with reddish or black pustules. This prevents the normal manufacture of food and its storage in the roots, thereby decreasing next season's yield. Rust overwinters as teliospores that can cause infection of the young shoots in the spring. The rust fungus thrives best where dew or fog is prevalent and soils are dry.

Control

Burn the diseased tops late in the fall. A dormant application of a one percent Elgetol solution, using from 600 to 800 gallons an acre, applied at a pressure of 400 pounds, may reduce somewhat the spring stage of the fungus. The spray can be put on either in the fall or in the spring. During the harvest season all plants should be kept cut. Destroy all volunteer asparagus. Only resistant varieties should be planted. Mary Washington and Martha Washington are resistant varieties widely used in New York.

BEANS

Anthracnose

Anthracnose (*Colletotrichum lindemuthianum*) produces black sunken cankers on the pods. In the center of the spots is a salmon-colored ooze. Similar lesions are found on the young cotyledons and on the stems. Blackened dead portions of the veins on the underside of the leaf may be noted. The stems may be rotted off just as they emerge from the ground or the cotyledons may be destroyed. With either condition the plant dies or becomes worthless. Later infections may harm the pods and seeds. Mature infected seeds may be discolored.

The fungus overwinters in the seed and refuse left in the field. It does not persist long in the soil without beans and is not known to attack weeds or other farm crops. When infected seeds are planted, the fungus is pushed above ground on the cotyledons and from there it is scattered by the splashing and washing of rain, by insects, and on tools and clothing to all parts of the field. It grows through the pods and affects the new seed beneath the spot.

The disease is greatly influenced by the weather and is worse in rainy weather with high humidity and temperatures between 63°F. and 75°F. Water must be present before the spores are liberated.

Control

Certain general recommendations that have proved beneficial include: fall plowing of all diseased refuse, practicing three- to six-year rotations with other crops, using well drained soil, refraining from cultivating the field when the plants are wet, and keeping the field free of weeds so that the plants will have good air drainage.

The principal control measure, however, is to plant healthy western-grown seed. At present the majority of red kidney and snap bean seeds planted in New York come from the Sacramento Valley in California or from Idaho because these areas are generally free of both anthracnose and bacterial blight. Varieties are being developed with resistance to most or all strains of anthracnose. These include Robust, Monroe, Sanilac, Michelle, Cooper's Wax, Improved Perry Marrow, Logan, and Clipper.

Bacterial blight

Early symptoms of bacterial blights (*Pseudomonas phaseolicola*, *Xan-*



Figure 1. Asparagus rust (*Puccinia asparagi*)



Figure 2. Halo blight of beans (*Pseudomonas phaseolicola*)

thomonas phaseoli et al.) may be confused with anthracnose, although all mature lesions are quite distinct. At least three prominent injuries are produced on an infected plant. Large brown blotches often bordered by a yellow or reddish halo are the distinctive symptoms on the leaf.



Figure 3. Common bacterial blight on Black Valentine beans

The whole leaf may die later, and defoliation of the plant takes place. The second symptom is caused by a girdling of the stem at one of the lower joints so that the whole plant wilts or falls over (sometimes known as tipover). The third pronounced symptom is the canker on the pod. This rarely is circular as in anthracnose and never is coal black or deeply sunken. The blight causes rather indefinite water-soaked spots, usually with reddish margins on the pods. At times a white or yellow ooze may appear on these affected pods. The infected seed may be discolored, but more frequently it is not.

Bacterial blight is caused by any one of six bacterial species whose life histories are similar. The organisms live overwinter in the seed, in the bean refuse in the field, or in the bean straw. Their life histories, so far as the infection of the young plants and the spread of the disease is concerned, are the same as for the anthracnose fungus. In addition, the bacteria may enter the plant at any point and pass entirely through the water ducts without causing external symptoms. Thus bacterial blight is spoken of as being systemic in nature. For this reason, it is impossible to state whether beans are free from the disease even though the pods in which they grow appear perfectly normal.

The common bacterial blight, which causes very large blotches on the foliage (figure 4), occurs only in seasons when the average temperature is high, and rarely assumes serious proportions. Halo blight, which causes numerous small spots with halos (figure 2), occurs when temperatures are below average and abundant moisture is present. Halo blight is more destructive and requires constant attention.

During the past few years fuscous blight, caused by a strain of *X. phaseoli*, has become injurious, but is still of minor importance. It has been found especially on Michelite, but also on Marrow and other varieties. It causes a glistening yellow discoloration under the seed coat of white beans.

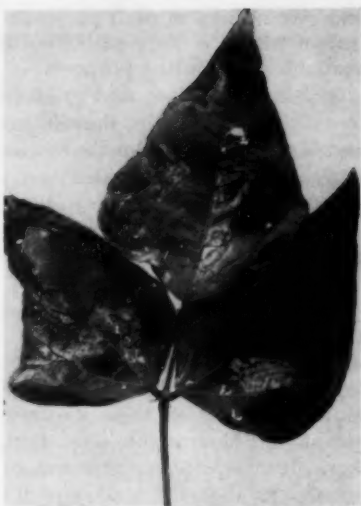


Figure 4. Common bacterial blight of bean (*Xanthomonas phaseoli*)

Control

The general control measures for bacterial blights are the same as those given for anthracnose (page 7), but the problem of harvesting healthy seed or the breeding of varieties resistant to bacterial blight is far more complicated than when only anthracnose is concerned. Because this disease is systemic, the bacteria may enter the seed by way of the water ducts

and give no sign of their presence. Therefore, pod selection for the control of blight is impossible. Furthermore, very few resistant lines are available for breeding purposes.

Although the bean seed producing areas of California and Idaho are free of bacterial blight, they do not produce sufficient seed for the East; and occasionally a carload is received here that evidently came from some other source, because of the large amount of disease found in the fields planted with this stock.

Storing seeds for two years kills most of the seedborne bacteria that cause common and fuscous blights, but this aging does not affect the halo blight or wilt organisms.

Varieties of beans such as Robust Pea, Monroe, Michelite, Yellow Eye, Perry Marrow, and old-fashioned Refugees are sufficiently resistant for seed to be grown successfully in New York. Strains of Red Kidney and White Kidney are being bred at Cornell and elsewhere and should be available to growers soon. Resistant snap beans are now being bred and also should be available soon. Fullgreen, a United States Department of Agriculture release, has pronounced resistance to halo blight, but the pods are shorter than the market prefers. Tenderlong 15 is resistant to halo blight and also has resistance to powdery mildew and common mosaic. Other resistant varieties are Corneli 14, Richmond Wonder, and Starland Wax.

Some pole beans, including Blue Lake and Kentucky Wonder, are sufficiently resistant to the four types of bacterial diseases to permit successful culture in New York.

Neither spraying nor seed treatment is effective in combating any of the bacterial blights. Antibiotics are showing promise as foliage sprays to prevent secondary spread of halo blight and may eventually find a use in seed fields. No recommendation is possible at this date.

Mosaic

Bean leaves affected with virus mosaic have irregular, light yellow areas merging with dark green patches that produce the characteristic mottling or mosaic effect (figure 6). The darker areas develop faster than do those having the yellow tinge. Therefore the leaf becomes puckered, especially around the midrib, and the edges cup downward. The affected plant may have a sickly yellow color, al-



Figure 5. Common bean mosaic

though it remains alive until the end of the season. Plants infected early rarely bear any seed, even though they may continue to blossom until autumn.

Mosaic is caused by a virus that may overwinter in the bean seed and occasionally in living white sweet clover roots. The virus is carried from one plant to another by aphids, by one leaf rubbing against another, or by transferring sap in any other way from one plant to another.

Infection is favored by high temperature and high humidity. The clover mosaic (yellow mosaic) also may attack beans. This mosaic is not carried in the bean seed but lives overwinter in clover, sweet clover, and gladiolus.

Control

Among the field beans, the old type of pea variety was so susceptible to mosaic that culture was impossible. It was replaced by the Robust pea, which is immune, or nearly so, to the older strain of the virus, but the Robust and Michelite both are susceptible to Burkholder strain 15 of the mosaic virus. A strain of Michelite that is resistant to these virus strains has been released as Monroe.

An extensive bean breeding program has been undertaken by workers in the United States Department of Agriculture, state experiment stations, and commercial companies. This effort has been successful in releasing many varieties with resistance to common mosaic, and a few also possessing resistance to rust and powdery mildew.

Seed treatment and spraying or dusting are of no value in the control

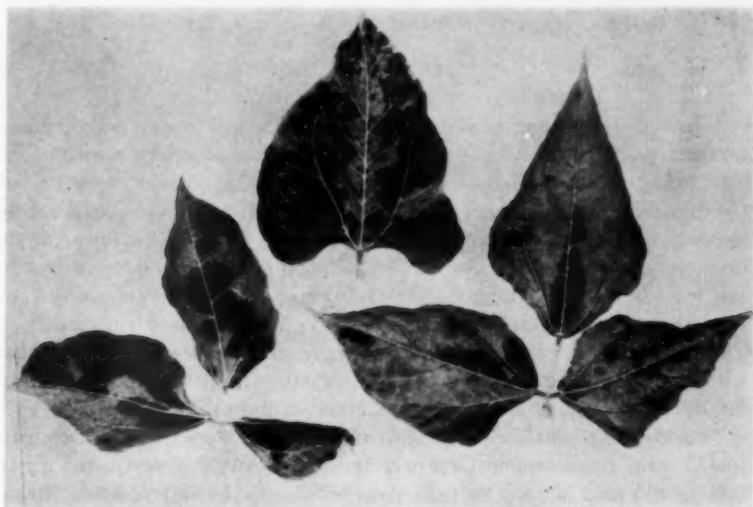


Figure 6. Common bean mosaic (*U.S.D.A. Photo*)

of mosaic. It has been suggested that the virus will die and a healthy crop can be grown if seed is kept for several years. This idea is erroneous, for the virus will remain active as long as the seed is viable.

If yellow mosaic becomes troublesome, beans should not be grown in areas immediately adjoining fields of clover, sweet clover, or gladiolus. Blue Lake, Refugee types, and Red Kidney are very susceptible to this mosaic. The virus is not seedborne.

Dry root rot

Root rot (*Fusarium* spp.) directly affects only the roots of the plants; however, the parts above ground are stunted and may turn yellow, wilt, and die before the plants mature. If infection is only moderate and rather general, the plants remain alive until harvest but the whole field will have the appearance of being undernourished as with a lack of nitrogen. The plants may be affected as soon as they emerge from the ground; usually, however, the trouble is more common on the older plants. When these are pulled, the side roots are found to be rotted away and the tap root has turned brick red and is hollow and dry. New side shoots may have formed on the stem above the lesion.

Root rot is caused by a *Fusarium* fungus that lives in bean refuse and also in the soil for several years. It grows into the roots and up through the water ducts, thereby causing the plant to wilt. The fungus rarely fruits before the infected stems or roots are old and have started to decompose. The spores and the mycelium are carried into the soil on tools and in bean straw manure. They may also be splashed by rain or carried by floods. The fungus affects no other crop. A *Fusarium* disease on peas looks very much like the one on beans, but the two are distinct insofar as the hosts are concerned.

Control

When putting into practice root rot control measures, one must remember that the pathogen is not seedborne, but that it is strictly a soil organism. Because it is carried with the bean straw, this should never be fed to animals for the manure will carry the organisms. The bean refuse should always be hauled where beans probably will not be grown for six or more years. It is not known how long the root rot fungus can live in the soil. It has been demonstrated, however, that where a six-year or longer rotation is practiced, the disease is held in check sufficiently to grow a profitable crop. On the other hand, it has also been shown that where the usual three-year rotation is practiced, root rot increases until finally bean growing in those fields becomes impossible.

In addition to correct disposal of the bean straw and long rotations, a few general recommendations may be made: Any diseased bean refuse left on the field should be turned under deeply by fall plowing. Beans should be planted only on well drained, well fertilized soil that is likely



Figure 7. Dry root rot of beans (*Fusarium solani* f. *phaseoli*)

to give an excellent growth of vines. Close cultivation should be avoided. If the base of the plant rots off and new side shoots form above the lesion, the plant may live if the newly formed roots are not cut off by the cultivator. The more plant food available in the soil, the faster these side roots will form and the more chance there is for recovery.

Seed treatment and spraying are of no value in the control of root rot. Robust, Michelite, and Hodson Wax are fairly resistant and can be grown successfully in contaminated soil.

White mold

Sclerotinia sclerotiorum can attack all above-ground positions of the bean plant. The first symptoms are irregularly shaped water-soaked spots on the stems followed soon by similar spots on the branches, pods, and leaves. Under cool, moist conditions these may girdle the stem to cause a wilt and death. Infected pods soon turn into soft watery masses with small brown drops of liquid appearing in the white cottony growth. These white areas on the pods look like snow patches. Soon small, hard black bodies appear scattered in the cotton. These are the seeds or resting spores of the fungus that hold it overwinter. Pods slightly infected in the field will break down rapidly in the shipping baskets to cause "nesting."

Control

White mold increases as growers use closer spacing, more fertilizer, and irrigation. High humidity and high soil moisture favor the disease; therefore any methods that reduce moisture and humidity will be helpful. Wider row spacing, locating fields away from windbreaks, strict weed control, and long rotations are important. Since the sclerotia or "seeds" stick on the straw and pods, these materials should not be fed to animals if the manure is to be used on bean ground. Using non-susceptible crops like wheat, oats, rye, or corn between bean crops also will reduce losses. Chemical sprays or dusts using Terraclor (PCNB) at the time of first bloom, preferably after the last cultivation, have reduced the disease. Twenty pounds per acre of 20 percent dust or eight pounds of 75 percent wettable powder are suggested.

BEANS (Lima)

Downy mildew

The most conspicuous symptom of downy mildew (*Phytophthora phaseoli*) is the white downy mold on pods. The fungus grows through the pod into the bean, which finally shrivels, dies, and becomes black. Such black dried pods are common in badly infested fields. The fungus also attacks the young shoots, flowers, and leaves. White mycelial webs appear very sparingly on the leaves, but the veins may be purplish in color, twisted, or otherwise distorted.

The time of incubation of the fungus is so short, the amount of inoculum so abundant, and the means for dissemination so nearly perfect that within a few days it can sweep over a field and leave nothing but blasted pods. Much of the early infection comes from diseased seed. Within a few days fruiting bodies are formed on the surface of the pod, stems, or leaves,

and the life cycle is repeated. Bees collecting the nectar carry the fungus spores from diseased to healthy blossoms. The wind and splashing rain are also important factors in dissemination.

Downy mildew is most abundant in areas where night temperatures are low and mid-day temperatures are relatively high. Lima beans on Long Island are particularly prone to develop mildew. Fordhook types are much more readily attacked than Henderson Bush types. Breeding for suitable resistant strains is underway at Cornell and elsewhere. Thaxter is a new variety with good resistance.

Control

Long rotations, destruction of the diseased vines in the fall, and the selection of seed beans from a healthy crop are three important steps in controlling downy mildew, bacterial spot, and Diaporthe pod or leaf spot. Western grown seed is recommended.

As a supplement to these measures, spraying weekly with maneb, captan, nabam with zinc sulfate, zineb, or fixed copper will give good control of these three diseases. Copper should be used sparingly, for it may result in pod spotting on fresh market beans. Since these diseases occur only during certain years and their extent cannot be foretold, it is necessary to use fungicides each year. The grower must decide whether the disease losses have been frequent enough to justify the use of fungicides. In New York applications need not be made before July 15. The sprays can be combined with insecticides for the control of bean beetle and two spotted mites.

Bacterial spot

Lima bean leaves affected with bacterial spot (*Pseudomonas syringae*) have small, reddish brown, irregular spots in which the tissue is thinner than that of the normal leaf. As the dead cells become dry, the center of the spot turns grey and may crack open or fall away. On the lower leaf surface the veins may turn red or reddish brown. Other spots, more elongated than those on the leaves, are produced on the stems or pods.

The bacterium causing spot is also known to cause blight of horse beans, pear, sweet cherry, sweet sorghum, flowering balsam, stocks, lilacs, cowpeas, and common beans. It probably never lives overwinter in the seed and bean refuse. It spreads rapidly from lilac and wild cherry during wet weather when the temperature is about 85°F.

Control

The crop should be sprayed as suggested for the control of downy mildew. The bean fields should not be near lilac hedges, and all kinds of wild cherries should be eradicated.

Pod blight

Pod blight (*Diaporthe phaseolorum*) is confined mostly to lima beans and is more destructive to the pole limas than to the bush varieties. It has been reported on peppers also. There is a similar disease on soybeans, but the fungi are different. The disease seldom is found upstate because of the cooler climate, but may occur on Long Island when the summer temperatures and rainfall are higher than usual.

Large brown patches are produced on the leaves. Young pods rarely are infected. On the older pods, brown dead areas may be formed with many minute black pimples; or the black pimples may be present without any tissue discoloration. These same black bodies are also on the leaf spots and are the fruiting bodies of the pathogen.

The fungus lives on and in the seed and in the old refuse in the soil. It is able to remain alive in the soil for two or three years. It is disseminated with the seed or, in the field, by splashing rain or washing dirt.

Control

Since the disease has been found mainly in the states bordering on the Atlantic, seed should not be obtained from this area. Western grown seed is recommended. At least a four-year rotation is desirable. In addition, spraying or dusting as suggested for the control of downy mildew and bacterial spot will keep the fungus under control. The fungicides should be applied before there is danger of widespread infection.

Lima bean mosaic

Lima bean mosaic is caused by a strain of the common cucumber mosaic virus. It also attacks cucumber, Turkish tobacco, zinnia, tomato, pokeberry, eggplant, pepper, petunia, horse bean, and cowpeas. The disease is more likely to be prevalent on the small Sieva type limas than on the large Fordhook types. Among the resistant varieties are Fordhook, Challenger, Burpee Best, Carpinteria, Large White, and Leviathan.

Control

Lima bean mosaic is not carried in the bean seed but is transmitted by aphids from overwintering hosts. The destruction of weed or flower hosts and the growing of resistant varieties are recommended as control measures.

BEET

Cercospora leaf spot

Cercospora leaf spot fungus (*Cercospora beticola*) produces brown spots with reddish purple borders on the leaves. These spots may drop out to give a ragged effect. They may be numerous enough to kill the leaf. Leaf

spot may become serious during rainy summers and be absent in dry seasons. The fungus also can attack pigweed, lamb's quarters, dock, lettuce, celery, sweet potato, soybean, and spinach.

Control

Control may be obtained with maneb, zineb, nabam with zinc sulfate, or fixed copper. The use of a long rotation is more practical however.

Black spot (Dry rot)

A deficiency of boron has been shown by Sayre to be responsible for black spot or dry rot. Black spots inside the beet or large black dry rot on external areas are symptoms. It is very likely to occur on alkaline soils or where lime has been used too recently to be effective.

Control

The amount of borax needed per acre is based on the pH of the soil; if it is above pH 7, 50 pounds of borax should be used. On slightly acid soils with pH 6 to 6.5, apply 20 to 30 pounds. On soils below pH 6 apply no more than ten pounds of borax.

CABBAGE, CAULIFLOWER, BROCCOLI, AND RELATED CROPS

Wirestem, black root, or damping-off

Crucifer seedlings are frequently attacked near the soil surface by soil fungi such as *Rhizoctonia solani*. They are greatly weakened by stem girdling and may even be killed outright. If infected seedlings are transplanted in the field, the disease will continue and result in weakened plants with inferior heads. This wirestem condition develops readily in cool, moist soil with high humidity at the soil line.

Control

Seedling beds should be watered as seldom as is consistent with good plant culture. Avoid plant crowding as much as possible and protect the plants in coldframes from fog or rain. Watering should be done in the morning and preferably on a sunny day. Stirring the soil surface after watering reduces damping-off. The pitch of the sashes should be at least four and one-half inches to prevent excessive leakage, and the glass panes should be as large as possible. Broken panes should be replaced immediately and all sashes kept well puttied.

Certain chemical treatments applied to the soil or plants will give good control of wirestem and damping-off:

(1) Corrosive sublimate (1-2000) is made by dissolving one ounce of the chemical in one gallon of hot water and then diluting it to 15 gallons.

One pint of this solution may be applied to each square foot of bed just after seeding.

(2) Treatment may be delayed and later directed along the base of the plants by applying a thin stream of solution at the rate of one pint for each four feet of row when plants are small, and two feet when they are large. The plants then must be immediately sprayed with water to remove the chemical from the leaves and to avoid burning. Two or three weekly applications of chemical should be adequate.

(3) Dusting the soil with a mixture of calomel, corrosive sublimate, and ground limestone is useful also. Mix one pound of calomel and one level tablespoon of corrosive sublimate with 17 pounds of ground limestone. A large jar with shaker top is convenient for shaking the dust on the soil just before the plants emerge.

(4) A mixture of Terraclor (PCNB) and captan has proven very effective, economical, and safe when one cup of 20 percent Terraclor and one cup of 7½ percent captan dust is worked into the top four inches of each 100 square feet of plant bed before planting. These chemicals may be applied as a soil drench immediately after planting by mixing one-half pound of 75 percent Terraclor and one-half pound of 50 percent captan in 100 gallons of water and applying at the rate of one gallon over 20 square feet. The use of this mixture affords effective control of *Pythium* as well as *Rhizoctonia*.

Black rot or blight

Black rot or blight (*Xanthomonas campestris*) attacks many crucifers, including cabbage, cauliflower, kohlrabi, Brussels sprouts, turnip, broccoli, and rutabaga. The bacteria live on and in the seed or in plant refuse in the soil. They also may live from one season to the next in seedbed soil, especially in coldframes and hotbeds. The bacteria may be spread by the blowing of the leaves, by rainwater, and possibly by insects. After gaining entrance into the seedling, the bacteria cause a yellowing or browning of the foliage which then shrivels and dies. Young plants may be killed outright, but in older plants, the organisms merely blacken and kill the veins through which they advance. On cauliflower leaves, the disease may express itself in the form of numerous minute brown specks resembling peppery leaf spot or downy mildew. It also produces a typical black ring in the stem. The heads may be dwarfed or one-sided and later may decay, falling off in a slimy heap. For this reason the disease is sometimes called stump rot.

Control

Too much emphasis cannot be placed upon using hot water treated seed (see page 85) and uncontaminated soil for the seedbed. Cabbage insects should be controlled and three- or four-year crop rotation practiced. If there is any chance that the seed flats or beds are contaminated,

the soil should be sterilized with steam, formaldehyde, chloropicrin, Vapam, or 2X methyl bromide.

Black-leg

Black-leg (*Phoma lingam*) was formerly a serious disease of New York cabbage and cauliflower. Suitable controls have now nearly eliminated it. Cabbage, cauliflower, Brussels sprouts, and other crucifers are affected. The first symptom is a sunken area on the stem near the ground line which extends in size and depth until the stem is girdled. Small black dots, the fruiting bodies, develop within the lesion and bear numerous spores. The spores are splashed by rain or carried by insects to neighboring stems and leaves where new infections arise. The fruiting bodies develop upon the affected leaves just as upon the stem. Their presence in the dead areas is an excellent diagnostic sign. The organism may live for at least three years in the soil and is carried on and in the seed. When infected seed is planted, the dead seeds permit the fungus to live and fruit in the soil while the cotyledons of the viable ones push above the soil to serve as a fruiting place for the parasite. Infection also occurs at the base of the new stem from the mycelium harbored under the seed coat. Dissemination and inoculation take place rapidly. In wet weather, a few infected seeds may be the source of an epidemic later. A common cause of such an epidemic is the practice of pulling up a large number of young plants and placing them together in water. If spores are present, every seedling may become contaminated.

Control

Since the fungus persists in the soil for three years, it is necessary to practice at least a four-year rotation. The diseased stems and leaves should not be fed to cattle, and great care should be exercised to prevent the spread of diseased cabbage refuse to other parts of the farm. If one field is infected and another is healthy, it is well to use different tools in cultivating the soil of each, for the fungus may be carried readily from one place to another. No seedlings should be transplanted from a seedbed that shows even a trace of infection. The seedbed should be on soil that has never grown cabbage or related crops. The seed must be hot-water treated. Field fungicides are of no benefit.

Fusarium yellows

Yellows (*Fusarium conglutinans*) attacks cabbage most severely and occasionally may affect Chinese cabbage, turnip, collards, cauliflower, broccoli, Brussels sprouts, kohlrabi, and kale. The fungus lives in the soil and, once established, remains there indefinitely as a potential parasite. It enters the plant through the roots, spreads upward through the vascular system, and causes the plants to have a sickly, yellow, dwarfed appearance. Frequently the edges of the leaves change to a lavender or

purplish color, and the base of the leaf turns brown. Usually the lower leaves drop one by one, beginning at the base of the stem. If the head has formed already, it will be left bare at the top of a naked stalk.

A cross section of a cabbage stem infected with yellows shows discolored vascular bundles similar to those found in plants infected with black rot. In fact, a microscopic examination must be made to distinguish definitely between yellows and black rot.

An abundant supply of potash reduces somewhat the severity of the disease. The fungus grows best at high soil temperatures, the optimum being about 82°F. Some varieties of cabbage, bred for resistance, retain that quality even under high temperature conditions. They are considered to have type A resistance. Others resistant only at relatively low temperatures have type B resistance.

Control

The only effective measure is to use resistant varieties. Many strains have been developed from the older varieties, and are now being widely grown. The grower should select the strain and maturity class that best suits his market needs. A partial list of varieties with the number of days to maturity includes: Wisconsin Golden Acre (60), Resistant Detroit (67), Badger Market (67), Jersey Queen (67), Greenback YR (74), Charleston Wakefield (80), Racine Market (80), Marion Market (85), Globe (88), All Head Select (85), Wisconsin Ballhead (91), Wisconsin All Seasons (92), Imperial Wisconsin All Seasons (92), Badger Ballhead (91), Imperial Wisconsin Ballhead (97), Empire Danish (97), Pennvalley (100), Wisconsin Hollander (113), Red Hollander (113), and Resistant Flat Dutch (116).

Moss Curled Dwarf kale is very susceptible to yellows. Thousand-headed kale has medium susceptibility, and Siberian kale is resistant.

Calabrese, De Cicco, Waltham 29, Early Green Sprouting, Midway, and Grand Central broccoli can be grown successfully in yellows soils, as can Early Snowball cauliflower, even though they are not completely resistant.

Clubroot

Clubroot (caused by *Plasmodiophora brassicae*) is without doubt the most serious disease of cabbage and cauliflower in New York. Plants affected with clubroot have yellowish, sickly leaves or green leaves that wilt on hot days. Young plants may die outright and older ones may fail to produce marketable heads. Roots of such plants are much enlarged and misshapen (figure 8). These malformations vary in size from tiny swellings on the smaller roots and rootlets up to large clubbed masses that later decay and give off bad odors.

Nearly all cultivated crops that belong to the mustard family are susceptible to clubroot. The common mustard so widespread in New York is extremely susceptible. Fortunately, winter cress is immune.

The disease is caused by a parasitic slime mold that gains entrance

through root hairs and injured roots. After the roots swell, the body of the slime mold is transformed into a mass of spores that are released into the soil upon the decay of the host tissue. The spores are disseminated by infested soil or soil water and by contaminated manure. They are never carried on or in the seed. The organism can live in the soil for a period of at least seven years and can attack susceptible plants at any time during this period.

Control

The eradication of weeds that belong to the mustard family, the choice of well-drained soil, the elimination of all seedbeds that show clubroot, and the practice of long crop rotations are sound recommendations of long standing. Newer methods include the use of chemicals in the setting water.

The first real step in control is to locate the seedbed in an area where no diseased cabbage or crucifers have been grown, where no contaminated manure has been applied, and where no infested soil can be washed. The application of lime to the seedbed merely hides the presence of the disease. It does not protect the plants when they are removed from the infested soil and set into an acid soil in the field.

All beds suspected of contamination should be treated with chloropicrin, Vapam, VPM, or Mylone before planting, or drenched with corrosive sublimate as suggested for damping-off control.

Enough lime should be plowed down in the field to produce a pH of 7.2 or higher. At least 1,500 pounds of hydrated lime should be used each year; the remainder may be ground limestone. The following is a rough estimate of the amount of lime needed at the various pH levels:

Table 1. Approximate amount of lime per acre needed to control clubroot.

<i>pH of Soil</i>	<i>Lime needed (tons per acre)</i>
5.0	2.5
5.5	2.0
6.0	1.5
6.5	1.0
7.0	0.75
7.5	0.5
8.0	None

The type of lime used is important. Hydrated lime is better than ground limestone for the control of clubroot. Spring rather than fall applications are advised. If hydrated lime is applied long before the crop is planted, the lime changes to the carbonate form that is ineffective in controlling the disease. The percentage of calcium in the hydrated lime is not important so long as it is not air-slaked. In other words, if lime with a high percentage of magnesium can be purchased cheaply, it can be used satisfactorily for the control of clubroot.

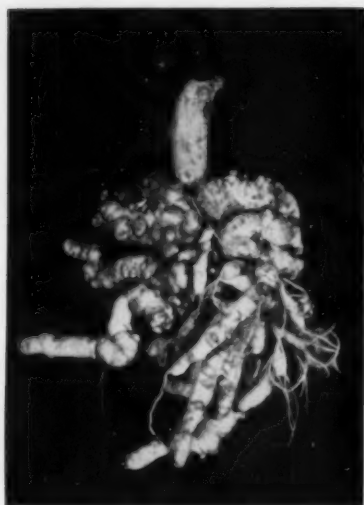


Figure 8. Clubroot of cabbage
(*Plasmodiophora brassicae*)



Figure 9. Downy mildew of cauliflower
(Note vascular involvement)

Chemicals in the transplanting water offer practical control. Terraclor (PCNB) has proved very effective at a rate of three pounds of 75 percent wettable powder in 50 gallons of water using one-third pint per plant. This requires 400 to 500 gallons per acre. Broadcast applications of 200 pounds of 20 percent Terraclor has been reported satisfactory in Oregon, but has been erratic here and is not recommended. The older chemical, calomel, (eight ounces in 50 gallons of water) is good but expensive. For cabbage or sprouts, corrosive sublimate (three ounces in 50 gallons of water) may be used, for it is cheaper than calomel.

New York crucifers vary in susceptibility in the following declining order: cabbage, Brussels sprouts, garden kale, charlock, white mustard, leaf mustard, worm seed mustard, candytuft, kohlrabi, cauliflower, radish, rape sea-kale, and tumble mustard. Rutabaga, stock-kale, yellow rocket, shepherd's purse, wallflower, dames violet, pepper grass, garden cress, stock and most turnips are very resistant.

Good progress is being made in developing resistant varieties of cabbage. This resistance may be extended to cauliflower and broccoli in future years.

Downy mildew of cabbage, cauliflower, broccoli, and radish

Downy mildew (*Peronospora parasitica*) occurs on nearly every species of cultivated and weed plant of the mustard family. Fortunately for the grower, each crop has a distinct strain of the fungus. Therefore, the fungus on cabbage, cauliflower, or any other related crop will not attack radish. The disease appears as a slight yellowing on the upper side of the

leaf. In moist weather a white mildew appears on the corresponding lower side. The spot enlarges until the leaf dies. In severe cases the whole radish plant or cabbage seedling may be blackened. On older cabbage plants only the outer leaves usually are affected.

The fungus reproduces very rapidly and enters the plant quickly. It overwinters in the soil as fungous threads and oospores, and probably is also carried in the seed. It is not known how long the organism can live in the soil without a host crop.

All downy mildew fungi are sensitive to environmental conditions. The spores will not germinate unless the air is saturated with water and the temperature is fairly low. Higher daytime temperatures enable the germ tube to enter the leaf. Conditions for the development of the fungus are almost ideal in a coldframe that is not properly managed.

Control

Coldframes should be run as suggested for the control of wirestem and damping-off (page 17). In addition, if mildew has been prevalent in the hotbed or coldframe, the plants should be sprayed with Cop-O-Zink, maneb or chloranil. The applications should begin as soon as the true leaves appear and continue on a five- to seven-day schedule until the danger of mildew is past. If mildew has been troublesome in a field in past years, the use of a fertilizer high in superphosphate and relatively low in potash, such as 4-12-4 or a similar formula, will reduce susceptibility to mildew. If manure is used generously in the plant beds, superphosphate should be added to reduce the effect of potassium on mildew. Field sprays with the previously mentioned fungicides will reduce mildew prevalence.

Broccoli varieties, Calabrese, Grand Central, and DeCicco, have good resistance to downy mildew. Dr. Natti is developing a resistant strain of Waltham 29. All cabbage, cauliflower, and broccoli seeds should be hot-water treated to kill seedborne mildew infection.

Alternaria black leaf spot

Black leaf spot (caused by *Alternaria brassicae*) is ordinarily only a storage problem but it may occur in the field near the time of harvest. The lower or outer leaves develop distinct black spots with concentric rings. In storage these spots may merge until the entire leaf is blackened. The fungus overwinters on crucifer refuse or on the seed. Once established in maturing senescent leaf tissues, the fungus sporulates freely. The dark spores are carried by wind or water to healthy tissues.

Control

Field sprays are not warranted although they would probably give good control. Hot-water seed treatment also destroys the seedborne inoculum. Careful handling of the heads during harvest to avoid bruising and permitting leaf surface moisture to evaporate before storing will reduce losses.

The storage temperature should be no higher than 34°F. with a relative humidity of 90 to 95 percent.

Tipburn of cabbage and cauliflower

Tipburn is a state of malnutrition that causes the tips of leaves to turn brown or black. When the trouble is slight, only the margins of the outer, older leaves are affected; but in more severe cases the outer leaves may die and the margins of the younger ones become distinctly tipburned. In the most severe instances, the entire plant is dwarfed and the head is flabby.

Control

Tipburn is generally attributed to potash deficiency, but more often is the result of an incorrect ratio of superphosphate and potash in the fertilizer. Decreasing the amount of superphosphate and increasing the quantity of potash frequently relieves the condition. Following a dry year, there may be enough residual superphosphate from heavy applications the previous year to produce tipburn in these crops. The 5-8-7 or 5-10-10 ratio is suggested where tipburn is likely to occur. Danish Ball-head cabbage is very susceptible to tipburn; early and kraut varieties are much more resistant.

Magnesium deficiency

Lack of available magnesium may result in yellowing between the veins of the plant leaves. The condition begins in the lowest leaves, and results in a chlorotic condition resembling mosaic; however, plants showing magnesium deficiency generally will appear over an entire field. Mosaic appears in plants at random in the field and in smaller numbers. With cabbage the lowest leaves may drop leaving the bare head. This condition resembles yellows or black rot.

Control

Magnesium deficiency can be corrected by applying dolomitic limestone or by using a fertilizer mixture containing small amounts of soluble magnesium salts. As a remedial measure where the disease is already appearing, the application of magnesium sulfate at the rate of about 40 pounds per acre will overcome the deficiency. This disease is fairly common on Long Island.

Boron deficiency

Boron deficiency may occur on all crucifers, especially broccoli and cauliflower in alkaline soils. In cauliflower the small leaves around the curd will become deformed and the curd will turn brown and be bitter. The core of both cauliflower and broccoli also may split crosswise and turn dark in color. Mottling along the margins of the old leaves and cross-hatching on the upper side of the petiole and midrib may be noted in

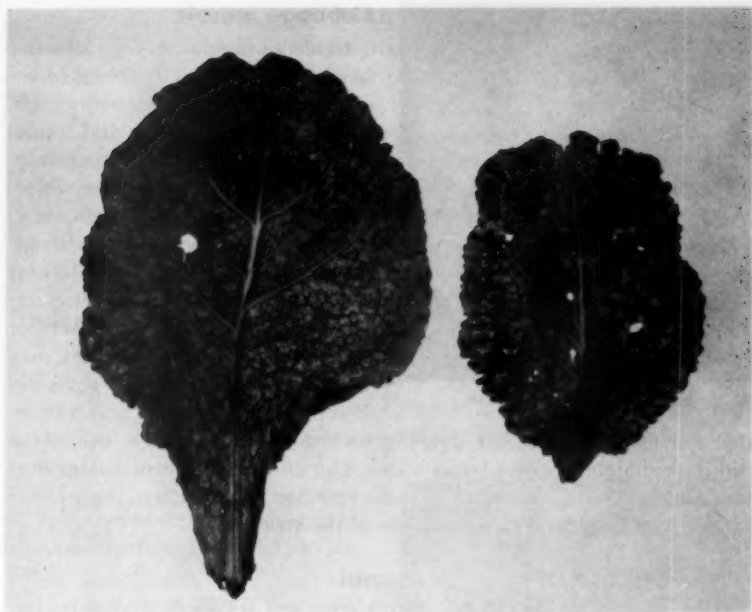


Figure 10. Magnesium deficiency of cabbage

cabbage. Upon cutting the head, water-soaked spots may appear in the pith of the stem.

Control

The addition of 15 to 20 pounds of borax per acre in the broadcast fertilizer should prevent this condition.

Whip-tail of cauliflower (Molybdenum deficiency)

During certain seasons whip-tail is prevalent, especially on Long Island. It is first noticed when the leaves become narrower and longer than normal. These leaves have a "quilted" appearance, are thicker than healthy ones, and are very brittle. The severity of the injury varies from complete absence of a head to production of a full-sized head.

Control

Whip-tail has been demonstrated to be the result of a deficiency of available molybdenum in acid soils. When the disease occurs, a soil test should be made in order to govern the amount of hydrated lime needed to obtain a soil reaction (pH) near neutrality. Work the lime into the sub-soil to make this area neutral also. Two pounds of ammonium molybdate per acre on the soil near the plants or four pounds broadcast has given good control of whip-tail.



Figure 11. Cabbage Mosaic

Cabbage mosaic

Cabbage mosaic, a virus disease, has become a great problem in recent years. At least two viruses, including turnip mosaic and cauliflower mosaic, may be responsible. Plants may resemble those suffering from magnesium deficiency, but only scattered plants will exhibit mosaic symptoms. The serious phase of mosaic is the black flecking or specking of the outer leaves of the mature head. This flecking may be present at harvest but generally becomes more severe and noticeable during storage.

Fields showing flecked heads at harvest should be sold immediately to avoid larger losses. The disease is most prevalent during seasons with high aphid populations for these insects, as well as imported cabbage worms, are carriers of the viruses.

Control

Wild mustard, yellow rocket, penny cress and shepherd's purse harbor the viruses. Control involves strict insect control with insecticides, elimination of weeds, and the use of available resistant varieties such as Empire, Badger Ballhead, Badger Market, and Penn State Ballhead.

Leaf blights

Leaf blight may result from an infection by *Alternaria dauci* or *Cercospora carotae*. These cause the leaves and petioles to turn yellow and then brown. With severe infection, the entire top of the plant may be killed, giving the field a fired appearance.

CARROT

Control

Regular weekly applications of fungicides beginning when the plants are six weeks old have given good control and an increased yield of 60 to 80 bags of carrots per acre. Maneb, zineb, ziram, nabam with zinc sulfate, or Bordeaux 8-4-100 are effective. Applications should be made before rather than after rainy periods.

Root knot nematode

(See page 89).

Storage rots

A number of rots may affect carrots under poor storage conditions. Usually these rots that are caused by various fungi and bacteria spread rapidly in the bin if the carrots are piled closely together.

Control

Carrots to be stored should be grown in three-year or longer rotations and sprayed as suggested above so that the roots are free from disease when they are harvested. The temperature of the storage should be as near 32°F. as possible, without excessive humidity in the air. No dripping water should be in evidence. Instead of solid piles of roots, there should be a layer of roots, then a layer of straw, old leaves, or other filler material. Only healthy unblemished carrots should be put into storage, and every precaution practiced not to break the skins of the carrots in piling them away for the winter.

Yellows

Yellows in carrots is caused by the aster yellows virus, the same virus that attacks lettuce. Symptoms include purpling of the tops and bushiness at the crown resulting from excessive petiole formation. The edible roots are woody and have many adventitious or "hairy" roots attached.

Control

For control measures refer to the discussion of lettuce yellows (page 46).

CELERY

Leaf blights

Three separate and distinct blights, all controlled by the same methods, attack celery and are characterized as follows: (1) early blight (*Cercospora apii*) produces dead, ashen-gray, velvety areas on the leaves; (2) late blight (*Septoria apii*) causes brown spots on the leaves and the stems, in which the tiny, black fruiting bodies of the fungus live; and (3) bacterial blight (*Pseudomonas apii*) produces spots that are more reddish brown than those of late blight, have a yellow halo about the lesion, and do not contain black fruiting bodies. Characteristic symptoms may appear on both the leaf blade and the petiole or stalk of the plant at any stage of its development. Plants in the seedbed as well as in the field are subject to attack.



Figure 12. Carrot yellows or purple top (Aster yellows virus)



Figure 13. Early blight of celery (*Cercospora apii*)



Figure 14. Late blight of celery (*Septoria apii*)

Celery blights lessen the attractiveness of the product and decrease its market value. When present to any extent, celery blights also retard growth, materially reduce the yield, and shorten storage life of the celery. All blights live over from year to year in the diseased portions of the plants that remain in the field after the marketable celery has been harvested. They also may be carried with the seed. The three pathogens are spread readily in the field by workmen or tools that brush against infected wet plants and then against healthy foliage. Early in the season the incubation period of the causal organism is probably from a week to ten days; later in the season it may be much longer. Infection of the leaves and spread of the disease are favored by rain and by moisture on the plant.

Control

For seedborne early or late blight, soak new seed in hot water of 118°F. for 30 minutes and then dry. Soil for the seedbed should be selected from a field that has not had celery for at least three years and which is free of nematodes. Fungicides are very necessary in celery production, beginning in the seedbed and continuing into the field. Any of a number of chemicals such as Bordeaux, maneb, zineb, nabam with zinc sulfate, or fixed copper may be used. Weekly applications should be made in the seedbed and begun in the field as soon as the transplants become established. In normal seasons field applications should be made every seven to ten days. In dry periods these can be stretched to 14 to 21 days. In very wet weather all the materials except Bordeaux and copper should be used on a five-day schedule. Apply chemicals just before cultivation; if any diseased refuse is in the soil, the cultivator will drag it to the surface where it will cause infection if the foliage is not protected. If disease has not appeared three weeks prior to harvest, continued spraying is probably not needed.

Even though spraying is done, long rotations should be practiced, and diseased refuse should be plowed under deeply. Cultivation or other work among the plants should be delayed until dew has disappeared.

Emerson Pascal and Emerald are resistant to *Cercospora* and *Septoria* and should be tried where these diseases have been destructive.

Storage rots

Late in the season a pink moldy rot sometimes appears on celery stalks in the field. More often it takes the form of a soft butt rot (*Sclerotinia sclerotiorum*) and appears in the trenches or in storage about seven weeks after harvest. On celery in cold storage this rot may be light brown with a gray mold on the outside (*Botrytis vulgaris*), or it may be a deep bluish green, nearly black, sometimes with a pink margin (*Phoma apiicola* or *Centrospora acerina*). Frequently it is a soft mushy bacterial rot (*Erwinia*)

and appears further up on the stalks and even on the leaves in the crate. All indications point to the field as the origin of these rots. Certain fields may gain a reputation for producing crops that have a very short storage period because of the presence of one or more of the three rot-producing fungi. Although no symptoms may be visible at the time of harvest, it is believed that the fungi gain entrance through the roots or the cut surface.

In rare instances the *Sclerotinia* fungus may cause a severe damping-off of celery seedlings. Similarly, under prolonged wet, cool conditions in the spring, *Phoma* may cause considerable rotting of the roots of young transplants in the field.

Control

Long rotations, deep plowing, and sterilization or changing of soil in the seedbeds are the only economical methods of control. It is important to keep a close watch on cold storage celery and to market it as soon as possible after the first symptoms of butt rot appear. A storage temperature of 32°F. should be maintained.

Yellows

Plants affected by yellows (*Fusarium* sp.) are stunted, yellowish, and the tissues tend to be brittle and bitter in taste. A longitudinal section of the stem at the crown of the root shows yellow or red vascular tissue. This may extend as far as the leaf veins. The fungus builds up in the soil with repeated croppings of celery. It is most destructive during warm seasons.

Control

The use of resistant varieties is advisable. These include: Emerson Pascal, Michigan Improved Golden, Golden Pascal, Cornell 6, Cornell 19, Michigan Green Gold, Florida Golden, Golden 99, Utah 15, Tall Utah 52-10B, and Pascal 284.

Brown spot

Brown spot (*Cephalosporium apii*) causes irregular tan to brown shallow lesions on the stems and petioles. The spots may be very small or they may be joined together to produce a cracked brownish area one or more inches in length. These elongated areas are likely to appear on the inner curve of the stalk. In rare instances, curling or distortion of the stem takes place. The cracked area somewhat resembles boron deficiency. The fungus does not penetrate below the outer layer of cells, but the unsightly condition reduces salability.

Brown spot is most prevalent during a season of high temperatures and may be almost entirely absent during a cool summer. The fungus is favored by a temperature of 75°F. and wet weather.

Control

The general control measures of crop rotations, good drainage, and destruction of perennial weeds are recommended. Spraying at frequent intervals with ziram, zineb, nabam, maneb, or Bordeaux is suggested. Eastern Pascal and Utah 10B are most susceptible and should not be grown where the disease has been present. Utah 5270 is most resistant but is not always suitable commercially. Utah 15 and Utah 16 are resistant and can be grown where the disease is prevalent.

Virus diseases

Eight or ten virus diseases have been reported on celery, but only two or three are of importance in New York. The foremost of these is the cucumber mosaic virus. It usually does not cause distinct mottling, but the leaves have a grayish cast, tend to be narrow, and the whole plant is more or less dwarfed. Infected plants in a field may vary in number from a trace to all of them. When so many are affected, the original source of the inoculum ordinarily is near or in the seedbed.

The other celery mosaic usually present produces distinct mottling and less severe plant stunting than does the virus mentioned above. It has not been actually identified at present. It may be the same as western celery mosaic.

Occasionally a strain of aster yellows, spotted wilt, or celery calico also may attack the crop.

Control

Seedlings should be grown at a great distance from the flowers and weeds enumerated under cucumber mosaic. If possible, the perennial weeds along ditch banks, roadways, and fence rows should be eradicated by chemical means.

Cracked-stem or boron deficiency

On many varieties of both early and late muckland celery, a severe transverse multiple cracking of the epidermis, chiefly over the ribs or vascular bundles may render celery unmarketable. The cracking results in a ragged saw-tooth appearance of the stalks and gives rise to such names as "rust" and "cat's claw." It is worse on new muck or in dead furrows and after deep plowing or heavy liming. It is caused by a lack of available boron. Thrips injury resembles the early stages of cracked stem, but thrips lesions are between the vascular ridges rather than on them.

Control

Light applications of borax have given good control. The amount should be regulated carefully since too much causes severe injury; from



Figure 15. Boron deficiency of celery
(Cracked stem)

15 to 30 pounds an acre in one application is safe and adequate. It may be mixed with the fertilizer, dissolved in the liquid fungicide, or applied directly as a sidedressing in mid-season. One application in two years is generally adequate. After two or three applications have been made, it may be wise to wait until symptoms again appear before repeating.

Black-heart

Tipburn of the central heart leaves followed by drying, blackening, and in some cases by secondary wet soft rot may cause sudden and severe losses at any time after celery plants are six or eight inches high. The cause of the breakdown of the fast-growing leaf tissue is not the

result of any organism but is associated with environmental or nutritional factors. Chief of these are high temperatures and humidities, probably during cloudy weather, as well as the presence of high soluble salts, especially nitrogen. The humidity is usually occasioned or accompanied by excessive soil moisture. Black-heart can be brought on in forty-eight

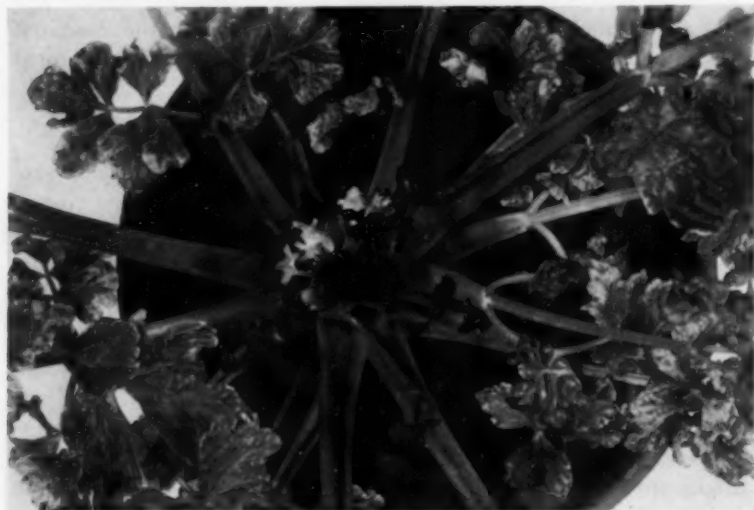


Figure 16. Black-heart of celery

hours by flooding, and is usually more severe in low spots. Calcium deficiency in the young, rapidly growing tissues of the heart may also be a primary cause of black-heart.

Control

Recent work by Dr. Geraldson in Florida has demonstrated effective control by using sprays of five to ten pounds of calcium chloride or ten to twenty pounds of calcium nitrate in 100 gallons of water. The spray is applied directly to the heart of the plants at weekly intervals, beginning five to seven weeks before harvest. Calcium applications to the soil appear to be ineffective. Providing good drainage, irrigating at regular intervals in dry seasons, avoiding excessive nitrogenous fertilizers, and prompt harvesting at maturity should also reduce losses.

CUCURBITS

Anthracnose

Anthracnose (*Colletotrichum lagenarium*) is usually present on watermelons and to a lesser extent affects muskmelons, gourds, and cucumbers. Squash and pumpkins are almost immune. The fungus produces angular black spots on the leaves and elongated black spots with light colored centers on the petioles. The small fruits are sometimes killed, after which they turn black and drop off. Older fruits have dark bordered cankers with flesh colored ooze in the center. Soft rots may follow in these depressed cavities. Resistant types of muskmelons may show pimples instead of cankers.

The fungus lives overwinter in diseased melon and cucumber refuse as well as in and on the seed. When contaminated seed is planted or old vines are present, the fungus is splashed to the new plants. There it may become destructive when weather conditions are favorable. The fungus requires a fairly high temperature and plenty of moisture for most rapid growth.

Control

The control methods are similar to those recommended for the control of cucurbit scab (page 35) except that seed treatment will not kill fungus threads that have grown into the seed.

None of the copper compounds are effective against anthracnose. Captan or maneb are recommended and have proven to be better than copper. During the early growth of the plants it is more satisfactory to use hand dusters than field sprayers. Only a few pounds of dust are required to cover an acre of young plants. It should be emphasized that light coverage is enough. A heavy dosage may cause injury to the young plants. Usually plants require protection only during the first five to six weeks unless rotation is not practiced or unless the crop is grown near diseased vines.

Santee, Palmetto, Stono, Ashley, Ashe, and Fletcher are slicing cucumber varieties possessing tolerance to anthracnose as well as to downy mildew. They are worthy of trial.

Fusarium fruit rot

During cool wet harvest periods *Fusarium* species often cause considerable fruit spotting. This is especially frequent on extremely rough netted varieties. When the weather turns warm and dry, little or no trouble is noted. These fungi are common contaminants of soil, but must enter through fruit bruises or injuries. At temperatures of 75°F. to 80°F. with high humidity after harvest or during shipping, the infected spots develop "dime-size" areas of white or pink mold easily removed with the fingernail. Soft rot bacteria may enter these spots and with the fungus cause off flavors or extensive fruit rot.

Control

Foliage fungicides are of doubtful value here. Pre-cooling and shipping under refrigeration are more effective in minimizing these losses.

Angular leaf spot

Angular leaf spot (*Pseudomonas lachrymans*) was formerly common and destructive in most of the older cucumber districts, but persistent control measures have nearly eliminated it from New York. It affects cucumbers, certain gourds, and a few less known plants of the same family. On squash the disease is caused by *Xanthomonas cucurbitae*, which has almost the same symptoms, life history, and control as the bacterium on cucumber.

The disease appears on the leaves, the stems, and the fruit. Spots on the foliage are irregular in shape, angular, and water soaked. In the presence of moisture, bacteria ooze from the spot in tear-like droplets that dry down into a white residue. The water-soaked area later turns gray and dies. The drying and shrinking of the dead tissue may tear it away from the healthy portion, leaving large irregular holes in the infected leaves. The spots on the fruit are much smaller and nearly circular. When the diseased portion dies, the tissue becomes white in color and may crack open.

The bacterium that causes the disease overwinters in plant refuse and on the seed. During rains it is splashed from the soil to the stems, leaves, and later to the fruit. After infection has taken place, the organism is transferred readily on the hands and the clothing of the pickers. Infection takes place through the stomata, and since they close during the night, most invasion takes place in the early morning after daylight but before the dew or the rain has evaporated. Inoculation may take place on the fruit just before picking. During lengthy shipment, much spotting may appear on fruit that seemed healthy when picked. Frequent rains and a temperature of 75°F. are optimum for the growth of the bacterium.

Control

Complete control can be achieved in seasons of low temperatures by treating the seed with corrosive sublimate and by using a two-year rotation. In other years fungicides are needed as for anthracnose. Maneb or captan are not as effective as is copper. Consequently, either fixed copper or Bordeaux should be applied every five to seven days as long as the temperature remains high enough for angular leaf spot to cause infection. If both anthracnose and angular leaf spot are present, the maneb or captan should be alternated with copper.

Scab

Scab (*Cladosporium cucumerinum*) attacks cucumbers, muskmelons, pumpkins, and sometimes squash. The infected leaves have water-soaked spots that later turn white and are distinctly angular in shape. Most of the dead tissue tears out and leaves a shot-hole effect. The stems also have slight cankers, but most of the injury is on the fruit where at first there is an oozing of sap as if there had been an insect sting. Later the spot increases in size and becomes a sunken cavity lined with an olive-green mold. The fruit finally may be destroyed by a soft rot. The winter squash, because of its resistance, may sometimes show only elevated calluses.

The scab fungus overwinters in old cucumber refuse, on the seed, and in the cracks about the greenhouse. It develops best in moist air and can cause infection at temperatures as low as 51°F.

Control

Two of the most important recommendations are crop rotation and corrosive sublimate seed treatment (table 2). In addition, spraying or dusting as suggested for anthracnose (page 33) may be necessary. When minimum temperatures of less than 57°F. persist longer than nine hours, no fungicides are effective.



Figure 17. Cucumber scab (*Cladosporium cucumerinum*)

Several new scab-resistant cucumbers are worthy of trial. These are: (slicers) Ashe, Fletcher; (pickles) Wisconsin SMR 12, SMR 15, SMR 18, Nappa 63.

Leaf spot

Leaf spots (*Macrosporium cucumerinum*) at first are small, circular and somewhat water soaked. Later they enlarge rapidly and may be recognized easily by their concentric rings and a definite margin on the upper side of the leaf. When heavily spotted, the foliage dies. The fungus lives over the winter in refuse, and during the summer is splashed by rains or carried by tools from one plant to another. Leaf spot is especially severe in moist, warm seasons. It usually occurs in epidemic form only where there are many weeds in the field or where there is a windbreak that permits dew to remain on the plants for long periods.

Control

The control of leaf spot is essentially the same as that suggested for cucurbit scab and anthracnose (pages 35 and 33).

Powdery mildew

Powdery mildew (*Erysiphe cichoracearum*) affects melon, cucumber, squash, pumpkin, and nearly every other kind of cucurbit as well as some unrelated plants and weeds. The fungus appears as a white mealy growth on the upper side of the leaves or petioles, although it can also occur on the lower sides under severe conditions. When the fungus grows luxuriantly, the foliage withers and dies. Fungus growth is favored by high temperatures and the absence of dashing rains.

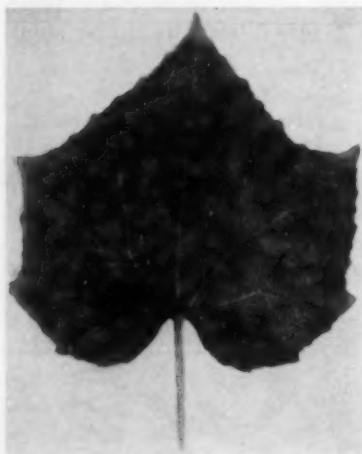


Figure 18. Powdery mildew of cucumber (*Erysiphe cichoracearum*)

Control

Our usual cucurbit fungicides are not effective against powdery mildew; however, a new chemical marketed as Mildex and Karathane has proven effective against this disease. The chemical may be applied either as a spray, using eight ounces of 22.5 percent wettable powder in 100 gallons of water, or 30 pounds of a one percent dust. A preventive schedule is not necessary; instead, one application made at the first signs of mildew and another made ten to fourteen days later is adequate. Spraying or dusting by air is effective also. Kara-

thane or Mildex should be used on dry foliage and preferably at temperatures below 90°F.; dusts may be used safely above this temperature. With careful usage, sulfur is also effective. It should be used in a 20-80 mixture, using 20 pounds of fused bentonite dusting sulfur with 80 pounds of pyrophyllite as a carrier.

Downy mildew

Downy mildew (*Pseudoperonospora cubensis*) often may be destructive on Long Island if weather conditions are right. It is rare upstate. It affects not only cucumber, squash, pumpkin, and muskmelon, but also a number of other closely related plants.

Irregularly shaped yellowish spots appear on the upper sides of the foliage nearest to the center of the hill. If the leaf is examined on the underside when dew or rain is present, the brown lesion will be covered, or at least bordered, by a purple fungus growth. The spots increase rapidly in size until the whole leaf withers and dies. In a badly diseased field it is common to find all the foliage dead near the center of the hill with only the young leaves remaining at the tips of the vines. Fruit formed during the attack will remain dwarfed and have a poor flavor. The fungus requires much moisture and high temperatures for best development. Its method of overwintering is not known. It is not believed to be carried in the seed.

Control

Long rotations and plowing under diseased vines immediately after harvest are good practices; however, the best control is obtained from thorough and repeated applications of maneb, fixed copper, or Bordeaux 8-8-100. The first two materials may be used as five to seven percent dusts. Captan, although recommended for other cucurbit diseases, is somewhat less effective than the above chemicals against downy mildew. Recent United States Department of Agriculture work indicates that a mixture of two pounds of fixed copper with two pounds of zineb per 100 gallons of water gives good mildew control. A sticker-spreader should also be added to this mixture.

New cucumber varieties resistant to downy mildew and anthracnose are Santee, Palmetto, Stono, Ashley, Ashe, and Fletcher. Another variety resistant only to downy mildew is Burpee's Hybrid. The adaptability of Santee and Palmetto to New York is not known; however, the other varieties are recommended.

Bacterial wilt

Bacterial wilt, (*Erwinia tracheiphila*), is one of the more serious diseases of cucumber, squash, muskmelon, and pumpkin.

The disease starts on a single leaf that gradually wilts and dies. The wilting spreads to the vine and finally to the whole plant. In certain squash that are rather resistant, there is no true wilting but a distinct

dwarfing of the vine. If an infected stem is cut crosswise and some of the plant juice pressed against the finger, the juice will string out if the finger is withdrawn slowly. The sap of the healthy plant is watery and usually does not string. Drops of bacterial ooze may collect on the surface of the fruit. The roots are not affected directly.

The disease is caused by a bacterium that can overwinter only in the digestive tracts of striped and the twelve-spotted cucumber beetles. In the spring the parasite is deposited on the cucurbit leaves in the droppings of the beetles. It enters the host tissues only through deep feeding wounds that penetrate the sap ducts and finally migrates to all parts of the vine. It is disseminated to other plants by deep-feeding insects and by pickers. Late in the season grasshoppers are effective carriers.

Weather conditions seem to have little direct influence on the disease. Any environment that favors the feeding of the beetles, such as moderately high temperature, greatly affects the number of infections. Winters with unusually deep snow followed by exceptionally warm weather in March and April favor the build-up of the insect carriers and wilt is usually severe.

Control

A few plants in the garden may be protected by enclosing them in cheesecloth tents. The cheesecloth is stretched over wooden hoops and anchored with stones or soil so that no insects can crawl under the covering. Large plantings of cucurbits must be protected by insecticides. Early applications of methoxychlor, rotenone, or malathion are greatly needed for beetle control.

Mosaic

Virus mosaic is perhaps the most threatening of all the diseases of cucumbers, squash, and muskmelons. In some of the older growing areas production of these crops has become unprofitable, and the disease is increasing in all the newer areas. If all growers do not take every control precaution or plant resistant varieties, the cucumber crop in New York is sure to be greatly diminished.

At least two distinct strains of virus affect cucurbits: cucumber mosaic virus and muskmelon mosaic virus. A similar but unrelated virus called ring spot may be serious on squash fruit. This virus forms distinct rings that often break down with secondary organisms.

The cucumber strain is by far the most prevalent and serious. It causes the normal green of the leaf to be mottled with light yellow areas (mosaic pattern). The fruit too may be mottled or have a much roughened surface, caused by knobs of green developing normally while the tissue between fails to grow. Sometimes the green color is almost totally lacking, and the disease then is known on cucumbers as white pickle. In severe cases the plants are yellow, burned, and very much dwarfed. Such plants bear few fruits.

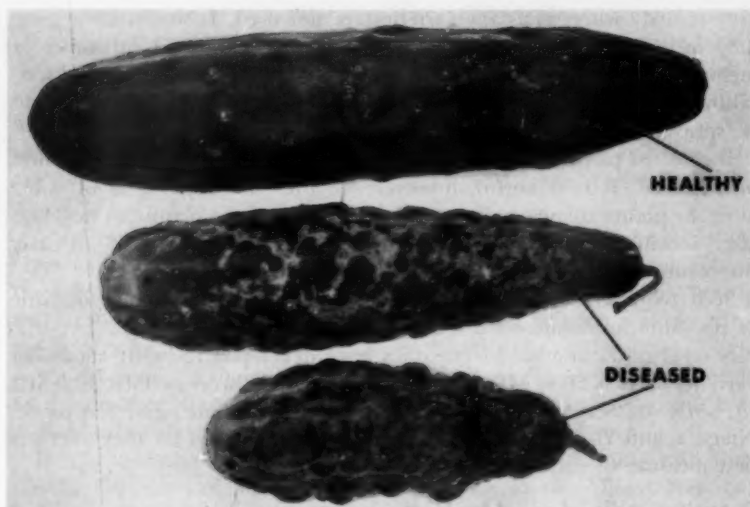


Figure 19. Cucumber mosaic

The mosaic diseases are caused by viruses in the sap of infected plants. The cucumber mosaic virus is not seedborne in commercial crops. It overwinters in the seed of the wild or bur cucumber and in the roots of perennial plants such as milkweed, catnip, mother-wort, pokeberry, ground cherry or husk tomato, phlox, plantain, hollyhock, wild bluebell, burdock, flowering spurge, and white cockle. When these plants come up in the early spring, the cucumber aphid, the striped cucumber beetle, and the twelve-spotted beetle feed upon them. The mouth parts of the insects become contaminated with the virus that they carry to cucurbit plants. Within five to ten days the new infections become visible. The virus may then be transmitted from plant to plant in the field by insects or on the hands of workers as they harvest the crop.

Control

The cucumber or melon field should be surrounded by cultivated crops (other than alfalfa) and should not be near buildings, grain fields, hedgerows, vacant lots, or other places where the susceptible weed hosts grow undisturbed. The weed host plants that grow in the cucurbit field or within 50 yards of its outer edge should be pulled up and destroyed or sprayed with a weed killer in the fall and in the spring. Wild cucumber, mother-wort, and catnip are by far the most important weed hosts in upstate New York. The field should be inspected for these weeds before the cucumbers or melons are planted or transplanted; inspections should be repeated at frequent intervals during the growing season until there is no more danger from infection. This is not an easy task, but it is the

only remedy where resistant varieties are not used. It would be a great help in weed eradication if the location of the next year's cucumber or melon fields were known in the fall so that the fence rows, ditch banks, or fallow areas where clumps of the carrier weeds are known to occur could be sprayed with 2,4-D or other weed killer.

If infected plants are found in the crop early in the season, they should be removed. It is doubtful, however, whether this roguing is of value after the plants are nearly grown. Only that part of the plant that develops after inoculation is much injured by the disease; therefore, if all early infections are avoided, the crop loss can be greatly reduced.

Seed treatment and spraying or dusting with fungicides are of little or no value in mosaic control except to hinder insect feeding.

Several states and seed companies have developed resistant cucumber varieties such as Ohio MR 17, MR 25, MR 200, Wisconsin SMR 12, SMR 15, SMR 18, Sensation Hybrid, Burpee Hybrid, Challenger, Nappa 61, Niagara, and Yorkstate. These should be tried and used for they offer the best measure of control.

Fusarium wilt of muskmelons

Fusarium wilt of muskmelons is caused by a *Fusarium* species distinct from that causing watermelon wilt. The disease is of declining importance now that resistant varieties are being grown so widely; however, it can still wipe out a crop of a susceptible variety. The first symptoms are stunting and yellowing of the vine. About this time a streak begins to form along one side of the vine and extends for a few inches or for the entire length of the plant. The streak at first is water-soaked, then becomes fawn colored or yellowish tan. In some plants there is no definite streak, but the vine cracks open, and sap oozes out and collects in amber drops. The plant soon dies. Infection takes place throughout the season. The fungus lives in the soil for many years and also may be carried in the seed. High temperatures favor its growth.

Control

Long rotations, sterilization of the soil in which the seedlings are grown, and destruction of diseased refuse are suggested precautions. The use of resistant varieties, however, is the only satisfactory control. Plant breeders in New York and Minnesota have developed high quality melons resistant to this disease. Where only heavily infested soil is available, the following varieties with good resistance are suggested: Harvest Queen, Iroquois, Delicious 51, Supermarket, Golden Gopher, Minnesota Midget, Minnesota Honey, and Harper Hybrid.

Malnutrition of muskmelons (Acid yellows)

An occasional yellow chlorotic condition of melons has been observed in local upstate areas for many years. Niagara County and other localities north of the ridge between Rochester and Chautauqua County appear

to be most prone to this difficulty. The affected plants are prominent because of their light green or yellowish green color, contrasted with neighboring dark green healthy plants. The length of the vines usually is normal except in the more pronounced cases, especially when the injury occurs on plants soon after the seedling stage. Under such conditions the stem may be much dwarfed. The plants blossom normally, but few fruits are set, nor does the fruit which develops grow large. The taste of the melon is insipid.

The injured leaves are light green or yellowish green between the veins with a dark green line a millimeter or more wide on each side of the vein. The more severely affected, the narrower the dark green strip will be and the more likely it is that the smallest veinlets will not show any of this vein banding. In extreme cases all parts of the leaf are light green except along the midrib and the principal veins emanating from it. In the most pronounced cases, all the leaves on the vine are affected; in others, only the leaves nearest the base appear normal.

It has been shown that the trouble is the result of faulty nutrition, possibly an excess of some mineral in acid soils. In the Albany area malnutrition occurs only where the sandy soil is extremely acid and is controlled by the application of lime. Most of the soils along Lake Ontario are not extremely acid, but the malnutrition is corrected by an application of lime which seems to tie up injurious chemicals in the soil.

Control

Although the exact cause of the malnutrition has not been definitely determined, it has been observed that certain conditions in the fields reduce the injury. If seeds are procured from sources where the injury is not present, the young plants seem to be more vigorous and the symptoms of the malnutrition are delayed. It has been observed that in soils between pH 6.0 and 6.5 there is less injury than in more acid soils. In nearly all cases where the injury is severe, the sandy soil is low in humus content; however, the most important environmental factor is wetness of the soil. During dry weather, a field of melons may show extreme malnutrition injury and recover almost fully after a heavy rain. Therefore, the recommendations are: to use seed that has been grown on normal soil, to select fields that are not too acid, to apply lime if the disease has occurred in the field previously, to take every precaution to fill the soil with well-rotted humus, and if possible, to irrigate during periods of drought.

EGGPLANT

Verticillium wilt

The fungus that causes eggplant wilt (*Verticillium albo-atrum*) affects many other cultivated and weed hosts. Among these are some as unrelated as peaches, muskmelon, tomato, pepper, and black raspberry. The disease

probably is present wherever eggplant is grown, and is so serious when it once becomes established that the growing of the crop is no longer profitable.

The wilt starts early in the life of the plant but usually is not noticeable until the crop is fairly well grown. At that time some plants may be smaller than others; the leaves may turn yellow, then brown between the veins causing the whole plant to suffer during the remainder of the season or to wilt and die. The tissue beneath the bark of the stem is discolored brown. The fruit is not directly affected. It is known that the pathogen is carried with the seed. After being introduced, the *Verticillium* fungus lives for many years in the soil. It may be brought in with soil on the roots of transplants or in other ways by which soil organisms are disseminated. It appears to be little affected by temperature but does require at least a moderate amount of soil moisture for best growth. The fungus thrives better in sandy soil or sandy loam than in heavy clay. Most important of all, the fungus grows best when the soil is alkaline; it grows slowly when the soil is very acid.

Control

Care should be taken to procure seed from disease-free fields or to treat it with hot water.

Once the disease has become generally prevalent in any given field, eggplant should not be planted in that field for many years. A new field should be chosen which has not produced wilt-infected raspberries, potatoes, tomatoes, peppers, or any of the other susceptible crops for at least ten years.

The application of sulfur to the soil has been suggested for the control of wilt. If crops other than potatoes are to be grown on this land, the sulfur may prove harmful. Consequently, it would be better to use a different field each year for eggplant, choosing those most acid.

Breeding of eggplant for resistance to wilt has proved somewhat discouraging, but there is some recent indication that success will be achieved with eggplant, tomatoes, and potatoes.

Phomopsis blight

Upstate New York is too far north for serious trouble with blight (*Phomopsis vexans*), but in certain seasons on Long Island and Staten Island the temperature becomes favorable for the growth of the fungus. So far as is known, it affects no other crop.

The fungus may cause trouble at any stage in the development of the plant from the damping-off of day-old seedlings to the rotting of ripe fruit. The young plants blacken and die. The leaves of older plants may be peppered with so many brown spots that they wither. The most serious phase of the disease, however, is the fruit rot. The fruit turns black, shrivels, and is covered with tiny black pimples that are the fruiting bodies of the fungus. The parasite overwinters in and on the seed

as well as in old diseased refuse. It can remain alive in the soil for at least three years. Aside from high temperature, it is not much affected by environmental conditions.

Control

The first requirement is a crop rotation of four or more years. An attempt also should be made to procure healthy seed. If the grower saves his own seed, these should be taken from fruits that are without blemish or disease. Northern-grown seed is more desirable than southern seed, which is almost sure to be infected. Only bright colored seed should be planted. If an appreciable proportion of the seeds show black spots, the whole lot should be discarded. Seeds of unknown origin should be soaked for 25 minutes in water heated to 122°F. After drying, dust seed with thiram, captan or Semesan.

The plants should be sprayed each week in the seedbed with ziram or captan. Similar applications also can be made in the field if the blight has appeared frequently enough to justify the expense. Maneb is especially effective for control of blight.

Two southern varieties, Florida Market and Florida Beauty, have good resistance to *Phomopsis* but are not very well adapted to New York.

LETTUCE

Bottom-rot

Bottom-rot (*Rhizoctonia solani*) is the most destructive rot of head lettuce in New York. The rot starts where the bottom leaves rest on the ground and generally works up into the head. It first destroys the blades of the leaves and then the midribs, but never rots off the main stem of the plant. It is caused by the very common and widespread fungus, *Rhizoctonia*, that attacks the plants from the soil and is very destructive when the lettuce leaves and the supporting soil remain moist. The pathogen lives in the soil, on growing plants, and on diseased plant refuse. Its greatest period of development is after the healthy plants have been harvested and infected plants have been left to rot in the field.

Control

An important practice is long rotations with such crops as sweet corn, tomatoes, cucumbers, radish, beets, onions, and spinach. If a field becomes heavily infested with bottom-rot, it may be advisable to plant some cereal or hay crop for a year or two.

All vegetable crops, particularly celery, carrots, and cabbage should be harvested promptly and removed from the field so that no fungi can reproduce on them. As soon as the lettuce crop is harvested, all the unused plants or other lettuce refuse should be hauled a considerable distance from the field and placed in a compost heap. Even though this entails



Figure 20. Lettuce drop (*Sclerotinia sclerotiorum*)

much labor, it has proved very effective in reducing the disease on newly cleared muck where the fungus is not so abundant.

Moisture can be controlled somewhat by planting in well drained soil that receives frequent shallow cultivation, and by eradicating the weeds in the field and along the ditch banks so there can be good aeration.

A new fungicide, Terraclor (PCNB), has given good control when applied as a spray just before thinning and then every seven days until a minimum of four applications have been made. Two and a half pounds of the 75 percent wettable powder should be mixed in at least 125 gallons of water per acre. Care should be used to get good coverage of the lower leaves and the soil under the plants.

In greenhouses, soil sterilization with steam, chloropicrin, formaldehyde, or high rates of methyl bromide will give good control.

Drop

Drop (*Sclerotinia sclerotiorum*) occurs in the greenhouse, coldframe and field. The rot begins on the stem near the surface of the soil and rapidly spreads upward, killing the leaves in succession until it reaches the heart. The dead tissue changes to a wet, slimy, decaying mass. The white fungus may grow over the entire plant and also form many black, variously shaped sclerotia that are the resting bodies. The pathogen remains alive in the soil for a long time and reproduces rapidly in lettuce refuse left in the field or in the beds where it is grown. The same fungus attacks nearly all other vegetables, especially carrots, cabbage, and celery.

Control

The recommendations for the control of drop are similar to those for bottom-rot (page 43). In the field a three-year rotation with nonsusceptible crops such as hay, corn, cereals, onions, beets and potatoes, is the most practical way to reduce drop. Dusting three times at ten-day intervals with a material containing seven percent fixed copper may give some control. This dusting is begun when plants are half grown. When plants are grown in coldframes, the sash manipulation should be similar to that suggested for the control of downy mildew: avoiding moisture droplets on the glass sash, keeping night temperatures three to four degrees higher than usual, having at least four and one-half inches of pitch on the sash, and keeping all sashes well puttied.

Tipburn

Tipburn (caused by unfavorable weather conditions) is one of the most destructive injuries with which lettuce growers have to contend. It is not severe on the early spring or late fall crop, but during the summer it may destroy the salability of nearly every plant in the field. On affected lettuce, the edges of the leaves die and turn brown; in severe cases it interferes with growth.

In a general way tipburn is known to be caused by weather conditions, chief of which is high temperature, but the exact combination of conditions is still unknown. Formerly it was believed that the hot sun shining on the succulent, fast-growing tissue caused the injury, but tipburn can originate even in the dark. It is a degeneration of the cells caused by faulty respiration that is brought about by high humidity, prolonged cloudy weather, and an abundance of soluble salts, especially nitrogen, in the soil.

Control

No definite control measures are known. A few precautions, however, may help to reduce the loss in a crop. Deep and frequent cultivations when the soil is packed by heavy rains, sparing use of potash and nitrogen, and medium applications of superphosphate have reduced the amount of tipburn in certain fields. Big Boston head lettuce is very susceptible, and it might be possible to substitute some other variety for the mid-season crop. Certain Iceberg strains, such as Cornell 456, Pennlake, and Empire are not immune but have produced marketable crops.

Yellows

Lettuce yellows (caused by the aster yellows virus) also is known as white heart because the center leaves become bleached and dwarfed. The head does not form even though the plant may continue to live. Young infected plants usually die. Old plants are not much injured by infection. The same disease is found on many weeds and cultivated crops. It is carried only by leafhoppers from one plant to another. Gradually it is becoming



Figure 21. Lettuce yellows (Aster yellows virus)

one of the most important diseases of lettuce, endive, escarole, asters, carrots, and other crops. It is especially serious on lettuce planted in mid-summer.

Control

If all the weed hosts within 300 feet of the lettuce field are eradicated, the disease may be reduced. Weeds can be eradicated by growing cultivated crops adjoining the lettuce or spraying the weeds on idle land with a weed killer. Very young lettuce plants should be sprayed regularly with DDT for leafhopper control. In most years the mid-summer crop requires this protection. Immediate plowdown of abandoned lettuce is highly necessary. If possible, late lettuce should not be planted next to lettuce that will be harvested earlier for the virus-carrying insects migrate to the new crop at harvest.

Mosaic

With mosaic (caused by a virus) the lettuce leaves become mottled with yellow and green, ruffled, or otherwise distorted and dwarfed. The entire plant has a sickly appearance and usually fails to bear a head. Most lots of seed carry three to five percent infected seed. When planted, these provide a source of infection to be spread further by aphids, the main vectors.

Control

Certain seed companies are now producing and offering for sale mosaic-free seed of most recommended varieties. The use of this type of seed,

coupled with a good spray program with parathion for constant aphid control, offers the most successful method of reducing losses from mosaic. This should begin at the time plants emerge. Breeding for resistance has been successful only with Parris Island, a romaine or cos variety.

Big vein

Big vein apparently was present a long time before it was recognized in California in 1934. Since then it has become an important trouble in several lettuce growing areas. In 1949 it suddenly became destructive on Long Island and in 1950 did much damage in some upstate areas. Since then it has been of only minor importance.

Infection may show at any stage of growth. Very young seedlings are killed outright. On older plants the first affected leaves have a pattern of pale colored, interlaced, enlarged veins. Later the plant is stunted, the leaves are crinkled and yellowed, or sometimes have dead areas between the veins. No head is formed on infected plants early. Even when the head forms, it usually is not marketable. In years favorable for the virus, the entire crop may be lost.

Big vein was formerly thought to be caused by a virus; however, recent work by Grogan in California indicates a water mold fungus, *Ospidium brassicae*, to be responsible. The fungus can live for long periods in the soil, and infection is favored by cool, wet soils.

Control

Soil fumigation or steaming should effectively prevent this disease. Where this is impossible, growing transplants at a relatively high temperature or planting outdoor lettuce as a mid-summer or fall crop will avoid the disease. The high temperatures of summer are unfavorable for big vein.

Stunt

The cause of this disease, often referred to as Pythium stunt, is unknown, although *Pythium* may be a factor in some instances. Affected plants exhibit dull leaf color or chlorosis and have wilted frame leaves at mid-day. A definite stunting also occurs, and poor secondary root growth with a brown discoloration in the vascular system is always present. Plants that are infected early in their life will eventually die; plants later infected will be stunted and produce small, loose, unmarketable heads. This disease has been sporadically important in



Figure 22. Lettuce stunt

our muck areas for many years, especially in Oswego. Cold, wet, poorly drained, heavily cropped mucks favor it.

Control

There is some recent indication that deep plowing and a three-year rotation free of lettuce will decrease the incidence of the disease. Preliminary work with soil chemicals has given no promising results. Further experiments are in progress.

Downy mildew

Downy mildew (*Bremia lactucae*) is injurious mainly in the greenhouse or in coldframes when proper ventilation is not used. It does, however, occur in the field under certain conditions, particularly early in the spring. The spots begin as lighter green areas on the upper surface of the leaves, and as the lesions enlarge, the fungus fruits with white mycelial wefts in corresponding spots on the opposite side. The affected tissue later turns brown. The whole plant may be dwarfed and yellow. The fungus overwinters on wild lettuce and occasionally on greenhouse lettuce. It requires a large amount of moisture for growth as well as cold nights and relatively warm days.

Control

Control consists mostly of correcting conditions favorable for growth of the fungus. In coldframes where the temperature often is rather low, the air should be kept comparatively dry or the mildew is sure to spread. In hotbeds and coldframes, special care should be taken to provide ventilation so that drops of moisture will not collect on the innerside of the glass and drip on the plants. Such moisture provides an excellent environment for the growth of the fungus. The pitch of the sashes should be at least four and one-half inches to reduce leakage. The glass panes should be as large as possible to permit good light entrance. The sashes should be well puttied and broken panes replaced. The fungus will not thrive in greenhouses if the night temperatures can be raised three or four degrees above normal for lettuce growing.

Several applications of zineb or nabam with zinc sulfate will give practical control of downy mildew. This is especially true in the field. Some of the Iceberg strains are especially susceptible to mildew. If an Iceberg variety is grown, only resistant strains should be selected, particularly for fall crops or in the northern part of the state. The leaf lettuce, Grand Rapids No. 1, is resistant and is recommended where mildew has been troublesome.

Gray mold

Gray mold (*Botrytis* sp.) is of little importance outdoors but is destructive occasionally under glass. Rotted plants are covered with a dirty gray, fuzzy mold, beginning on the leaves that are in contact with the ground.

The fungus mainly attacks weak plants, and in some measure gray mold can be prevented by obtaining vigorous growth. The coldframes should be handled as suggested for the control of downy mildew. In greenhouses the rot can be much reduced if the night temperatures are lowered as far as possible without injury to lettuce.

Control

The disease sometimes is troublesome on the early crop grown outdoors—infection coming from the seedling transplants that were grown in the greenhouse. This emphasizes the need for good chemical control in the greenhouse. Growing lettuce seedlings in sterilized soil, keeping the humidity as low as possible, and the use of a chemical spray program of Terraclor and captan mixture in the greenhouse, help to eliminate gray mold.

Damping-off and gray mold control in the seedbed

For many growers these diseases are serious problems in the greenhouse and coldframe. Many chemicals and methods have been tried as controls. Recent tests indicate the following chemicals and methods to be most successful. Before seeding, thoroughly mix a combination of Terraclor 20 dust and captan seven and one-half dust into the top four inches of soil, using half a cup of each over 100 square feet of soil. After emergence make several ten-day spray or drench applications of Terraclor 75 and captan 50 using only one-fourth of a pound of each chemical in 100 gallons of water and four or five gallons per 100 square feet of soil.

ONION

Smut

Onion smut (*Urocystis cepulae*) is common on New York muckland. It is not present in the southern United States where the temperatures are high. The presence of smut is first indicated by one or more dark spots at various heights in the leaves of the seedlings. These are more or less opaque when the plant is held up to the light. After a time, usually while the second leaf is developing, longitudinal cracks begin to appear on one side of these spots. These crevices widen and reveal a dry, fibrous mass that is covered by a black, sooty powder made up wholly of the ripened spores of the fungus. These spores are blown or washed into the ground. Similar smut lesions may show in the second leaf and in those formed subsequently. Plants thus diseased usually die early, especially if the soil is dry. Some may make considerable growth and survive up to the time of harvesting. In such specimens the smut shows as black elevations on the bulb, running down to the base and extending upward into the leaves.

The onion smut fungus lives from year to year in the soil. Instances are known in which onions planted in a smut-infested field after an inter-



Figure 23. Onion smut (*Urocystis cepulae*)

val of 27 years became severely infected by this disease. Only onions grown from seed are subject to smut, and these are only attacked by the parasite in the very young stages. Onions grown from sets or transplanted from soil free of the organism are not attacked. Sets grown on smut-infested soil, however, can carry the fungus to new fields. The spread of the disease from state to state is largely by means of these sets and locally by washing streams or in any other way that infested soil can be carried from one field to another.

Control

Because the fungus persists for such a long time in the soil, crop rotation is of little value in reducing the amount of smut in a field. Since onions can be attacked only in the seedling stage, the disease can be controlled by planting healthy sets, by seed treatment, or by sterilization of the soil with formaldehyde in the immediate vicinity of the germinating seed and seedling plants, as described in the following paragraphs.

Chemical Treatment for Smut and Maggot Control. Combination fungicide-insecticide mixtures have proven very effective in controlling both smut and maggots on onions. These chemicals can be applied by using several methods:

Soil drench at planting time—Formaldehyde and an insecticide are dripped or poured into the furrow with the seed from a tank mounted on the drill. It is important to apply one and one-half gallons of formaldehyde to the acre if rows are 14 inches apart, but to prevent seed injury, the formaldehyde must be diluted with water as follows:

	Formula and solution strength	Rate per acre	Feet row per gallon	Approximate time of flow per gallon
	<i>Gallons</i>	<i>Gallons</i>	<i>Feet</i>	<i>Seconds</i>
1.	1 in 65	100	375	90
2.	1 in 75	115	322	78
3.	1 in 100	150	280	67

For maggot control, add one pint per acre of aldrin 23 percent, dieldrin 15 percent, heptachlor 25 percent, or parathion 25 percent.

When muck is so wet that it sticks to the wheel of the drill, the first formula above should be used. On muck that has been fluffed up and has become partially dried out on top, the last formula must be used to avoid formaldehyde injury in the dry muck. The second formula has given excellent results in muck soils of average moisture content.

The rate of flow can be governed and tested in advance by inserting a union somewhere in the delivery tube below the solution tank. In the union are inserted lead, rubber, or leather discs that have holes of various sizes (less than five-sixteenths of an inch).

As the operator starts the drill, he opens the stopcock that starts the solution flowing into the furrow an inch behind the seed. To get the most even flow or distribution of solution whether the tank is full or nearly empty, it should be equipped with an air-tight cap. Air is then admitted through a small tube attached at the bottom of the tank, not the top.

Occasionally disappointing results have been obtained with the liquid formaldehyde method. In nearly every instance investigated, the reason has resulted from the use of insufficient formaldehyde per acre, insufficient solution to soak all the soil above the seed, heavy rains too soon after treatment, planting the seed too deeply, or occasionally heavy winds that cause drifting of the muck.

Pelleting of seed—For growers who refuse to use the drench method, the addition of a fungicide-insecticide to the seed by means of a sticker offers the next best control of smut and maggots. To do this, the seed is first moistened with the sticker solution made by 18½ ounces of Methocel in two and three-fourths gallons of lukewarm water. Add one pound (actual wettable powder) of aldrin, dieldrin, heptachlor, or parathion, and stir well. This is sufficient sticker insecticide to treat 100 pounds of seed at the rate of 105 cc. (three liquid ounces) per pound of seed. The seed moistening process is accomplished by pouring the correct amount of mixture on the seed, after which the mass is shaken vigorously to coat each seed. Then thiram 75 or captan 75 is added to the mass at the rate of one pound per pound of seed. The mass is again shaken for five minutes until the seeds are well coated. A "Red Devil" paint can shaker is excellent for this purpose. Seeds may be sown the same day if allowed to dry in a thin layer, or they may be hung in a bag in a cool, dry shed and held for several weeks. Several seed companies now offer this service free or on a custom basis to their customers.

Dust on the seed—Some growers refuse to bother with either of the

above methods. By placing one pound of thiram or captan with each three pounds of seed in the seeder box, good control has been obtained in Orange County. A suitable insecticide such as dieldrin also should be added for maggot control.

Downy mildew

Downy mildew (*Peronospora destructor*) is common in New York and may become destructive during cool, wet weather. Mildew seldom occurs early in the growth of the plant except on perennial or winter onions, where it may develop any time between April and October. The first commercial onions to show symptoms are the early crops grown from sets. These may be attacked early in June. Infection first shows as a dull, pale green spot usually near the tip of a leaf. During the night and early morning when dew is abundant, the fungus forms a pale purplish mold over the surface of the lesion. The spores borne on this lesion are blown to other leaves where they cause new infections. The old lesions weaken the leaves so much that they often collapse at those points and later turn olive green to almost black with secondary molds.

The pathogen overwinters in New York chiefly as vegetative mycelium in perennial, topset, or winter onions. It grows up into the tissues of the new leaves early in the spring and sporulates on them abundantly by the time the commercial crops are planted. In Europe it also has been found to pass the winter in some varieties of commercial bulbs as well as in oospores formed in diseased foliage. These hosts seem to be less important in New York than winter onions. Viable spores have been trapped 1,500 feet above a diseased onion field in July in central New York, so undoubtedly they are windborne.

Downy mildew requires plenty of moisture with rather cool nights and relatively warm days. When such a combination of weather occurs, an epidemic may be expected.

Control

The chief source of inoculum is winter onions that are present in many home gardens. If all such beds near commercial plantings of onions could be removed, much of the danger from mildew might be avoided. During recent years the removal of many of these diseased plantings within a half mile or so of muckland onions has gradually delayed the onset of field infections and lessened the severity of the losses. It is believed that elimination of all of these nearby sources of primary inoculum would practically eliminate the disease, or at least greatly reduce the extent of damage. Another recommendation is to refrain from growing early set onions in the same district with seeded onions because the early crop is likely to be infected by the mildew and then pass it on to the late crop.

Sometimes it is possible to select varieties that have smaller tops that dry quickly and do not mildew so severely as do those with larger tops.

The practice of using foliage fungicides on a regular schedule has been

the most successful measure for controlling downy mildew. This is discussed below under blast.

Blast

Various species of *Botrytis* are the primary cause of blast, a disease that causes severe losses to our muck onion crops in certain years. Other names for this disease include blight, tip blight, and tip-burn. Symptoms may be confused with other onion troubles, such as thrips, drought, downy mildew, and excessive soil moisture. Onions grown from seed are damaged more than those from sets, for the latter escape by earlier maturity. Blast symptoms include discrete papery spots on the leaves, soon followed by browning and death of the upper portion of the leaves. Immature, undersized bulbs result. Blast is favored by warm, wet weather.



Figure 24. Onion blast (*Botrytis* sp.)

Control of Blast and Downy Mildew

Effective control of these diseases and of thrips now can be obtained with regular applications of a fungicide such as nabam with zinc sulfate, zineb, or maneb, combined with an insecticide such as heptachlor, diel-drin, parathion, or DDT. A spreader, Orthol-K or B-1956, must be included to wet the leaves. From six to ten applications should be made at six- to eight-day intervals beginning in mid-June. In most seasons marked yield increases result from the use of this schedule. Dusting and aircraft applications are not as effective as spraying.

Neck-rot

Neck-rot (*Botrytis* sp.) may be serious on mature onions and on sets, and probably is present in every part of the world where onions are stored. In poor storages the loss may comprise nearly all of the total crop.

Neck-rot is confined to varieties of the common onion. The white onion is much more susceptible than is either the yellow or the red. The onion with a thin neck that dries easily is less susceptible than is a thick-necked onion of the same variety.

The disease seldom occurs on the bulbs while they are in the ground, although the fungus may attack injured leaves when the plants are young. The lesions that finally may involve the whole bulb first appear as sunken, dried-out areas about the neck. In cross section the scales



Figure 25. Spraying onions with fungicides and insecticides

appear to have been cooked. The tissue is soft and brownish. Between the scales is a gray mass of mycelium, and on the dried parts of the scales small black sclerotia begin to form. On the outside, particularly about the neck, sclerotia may form in a solid crust. Onions that do not have superficial sclerotia often have part of their surface covered with the characteristic



Figure 26. Neck rot of onion (*Botrytis* sp.)

ashen-gray fuzz of the fungus. Roots may be included also in the decayed area, especially if the bulb is attacked at its base. Occasionally soft rot bacteria follow the neck-rot and cause the onion to become soft, watery, and foul-smelling. Neck-rot, when unaccompanied by bacteria, results in a dry rot.

Neck-rot infection takes place through wounds at the neck of the bulb during or following harvest. The invaded area continues to enlarge while the onions are curing and after they are stored. The optimum temperature for infection is 68°F. to 75°F. The fungus seldom passes from bulb to bulb in storage unless the adjoining tissue is exposed by open wounds. Most rapid decay of the bulbs in storage is at temperatures between 59°F. and 68°F.

The *Botrytis* fungus survives the winter as sclerotia and as mycelium in the decaying bulb. The spores are blown by wind or carried on tools and clothing to the flower head, the leaf sheaths, the inner dry scales, and at harvest time to the cut tops and roots.

Control

If growers remember that mature, well-dried, well-stored onions are seldom infected, control will be fairly simple. First, the onions should be so grown that they will mature readily. Late applications of fertilizers and the presence of downy mildew, weeds, and wind barriers should be avoided. At harvest the tops should be cut fairly close and every attempt made to dry the stubs before placing the crop in storage. It has been demonstrated that mature bulbs or sets may be dried artificially to good advantage. They are placed in shallow trays and held at 90°F. to 120°F. for 48 to 72 hours. In addition, all thick-necked bulbs or scallions should be removed because their slow-drying qualities cause them to succumb quickly to the disease.

Onions should be stored in slatted crates that are stacked to permit air to circulate freely around them. The temperature should be kept as near 32°F. as possible and the humidity of the air at 65 percent. A steeply pitched roof with ventilators at the peak will aid in removing the warm, moist air. If the doors are then kept tightly closed on damp, misty days and opened only when the air is cool and dry, the amount of shrinkage from rot in an onion crop can be greatly reduced.

Onion bloat or bulb nematode disease

In three counties where onions have been grown continuously for many years and where onion sets are commonly used, losses from onion bloat have been increasing greatly in recent years. Bloat is caused by a nematode or microscopic eelworm called *Ditylenchus dipsaci* that lives in the soil and attacks all stages of the onion from the youngest seedling to a nearly mature bulb. Young plants become stunted and pale, and their stems and lower portions of their leaves often swell or become twisted, wrinkled, or otherwise malformed. Later in the season infested



Figure 27. Onion bulb nematode injury on onions

areas in a field of set onions can be detected from signs of wilting and yellowing of the foliage, accompanied by missing plants. The nemas living between the cells within the plant greatly weaken the leaves and in young bulbs produce a mealy or frost-like consistency that paves the way for secondary soft-rotting bacteria and fungi. Infested bulbs seldom store well even if they reach harvestable size. Such bulbs are light weight and, though slightly swollen, are often punky in texture. The bulb nematode can readily attack other crops in the onion family including garlic, leek, and chives.

Another distinct nematode strain affects Easter and Royal lily, narcissus or daffodil, hyacinth, and iris. Certain strains have been found also on a wide variety of other host plants including alfalfa, bull thistle, several clovers, dandelion, hawksbeard, oats, peony, potato, phlox, plantain, primrose, rye, strawberry, Sweet William, and teasel.

This nematode is much worse in wet seasons and in regions where humidity and rainfall are high or when irrigation is practiced; the nemas become active in water and lie dormant in dry soil. A very hot, dry August is believed to reduce greatly the number of nemas that can survive until the following season, while a cool, moist summer is sure to be followed by an increased amount of the disease the following season.

Control

The nematodes chief means of overwintering in onion fields is in diseased bulbs and plant parts left in the field after harvest. If a thorough

and complete cleanup is practiced at this time, the spread of the disease may be checked. Control cannot be expected unless this cleanup is combined with either fallowing or rotation with resistant crops such as carrots, corn, lettuce, spinach, asparagus, tomato, potatoes, beets, and broccoli. The practice of growing a cover crop of rye after harvest should be discouraged on infested land, for this crop can support the onion strain of the nematode.

The growing of potatoes or some other non-susceptible crop for a period of two to four years between onion crops is recommended as a way to eradicate this pest.

Great care should be exercised to prevent land on which sets are grown from becoming infested because diseased sets can carry the nematode to healthy fields. This means that one should never save bulbs from a field where the disease occurs and set them out on upland where sets are to be grown later.

Under certain conditions the nematode may be carried in the seed of oats, onion, and the legumes. Since good onion seed will stand a 25-minute soak in water at 125°F., it is likely that such a treatment could be used successfully to rid infested seed of nemas.

Recent studies have shown that soil fumigation is a successful means of controlling the bulb nematode. Fifty gallons per acre of D-D or Telone, applied in a single application; or two 25-gallon injections applied ten days apart give good commercial control. Treatment in the fall is superior to that done in the spring. (See soil chemical treatments, page 90.)

Root-knot nematode

(See page 89).

PARSNIP

Canker

The unsightly, chocolate brown discoloration on the white parsnip roots (caused by the fungus, *Itersonilia perplexans*) greatly reduces the salability of this vegetable. The browning is most commonly near the shoulder or crown of the root, but may also be present on the sides and downward almost to the tip. An inconspicuous leaf spot precedes the root infection. Spores shed from the leaf spots drop to the exposed shoulders to cause infection. The disease is most prevalent in a cool, wet season and in low areas of a field.

Control

Suggested control measures include the planting of parsnips only in well-drained soil, practicing crop rotation that avoids parsnips in preceding years, eradication of wild parsnips, hilling the soil several times during the latter part of the season in a ridge over the crowns, and in cool, wet seasons the use of fungicidal sprays. Copper, in the form of fixed copper or Bordeaux mixture, is the preferred fungicide. Weekly to

ten-day applications of Bordeaux 8-4-100 or fixed copper at the rate of four pounds metallic copper in each 100 gallons of water are recommended. Since the critical time for root infection appears to be from August 1 to the latter part of September, the spraying should be started slightly before that date and at least five applications made at ten-day intervals. Additional applications might be profitable during continued wet weather.

Root-knot nematode

(See page 89).

PEAS

Blight

Three blight diseases (caused by *Ascochyta* and *Mycosphaerella*) attack the pea, and the organisms causing them are so nearly alike that they are treated here as one disease. The disease appears as black to purplish streaks on the stem. The lesions are more pronounced at the nodes, where they enlarge into brown or purplish irregular areas and may extend as high as ten inches above the roots. The leaves become spotted in various ways. Sometimes the spots are small, purplish, irregular dots; at other times they are fairly large, almost circular, and may have concentric circles in them. On very susceptible varieties, the whole leaf may shrivel and dry. The spots on the pods are similar to those on the leaves except that on the fleshy pods the spots are sunken and do not have concentric rings in them. When the disease is severe, the plant may not emerge from the ground, it may die soon after emerging. Older plants do not succumb to the disease, but their yield is greatly reduced.

The pea blight is caused by three fungi, the life histories of which are almost alike. The fungi are carried in the seed and cause infection when

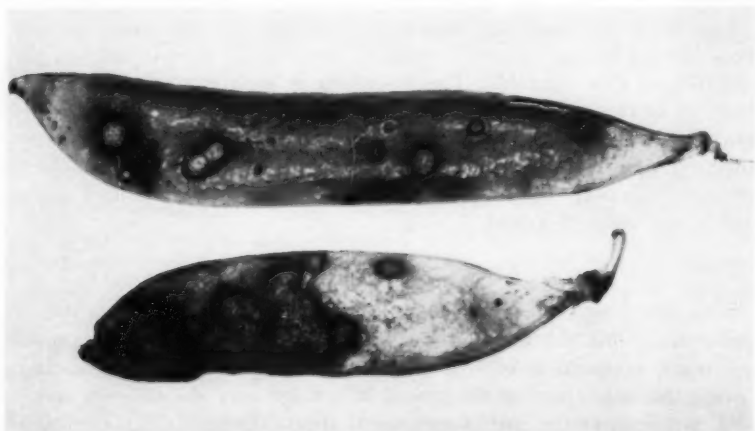


Figure 28. *Ascochyta* blight of peas

the plant is emerging. Rains splash the spores to neighboring plants until a whole field is infected. The diseased seed and the pea straw serve as places where the fungi may survive until the following season.

The optimum temperature for growth of the fungi is from 75°F. to 85°F. A rainy season is required for much dissemination of the disease.

Control

The general directions given for the control of pea wilt (page 60) apply equally well to blight. Well-drained soil, plowing under deeply all diseased refuse in the fall, and long rotations particularly are needed to control blight. The most important measure of all, however, is to procure healthy seed. It is strongly recommended that seed be brought from the far west where irrigation or dry-land farming does not permit the growth of the pathogens. Seed treatment has not proved successful against these diseases.

Wilt, near wilt, and fusarium root rot

Wilt (*Fusarium oxysporum* f. *pisi* race 1) is not as common in New York as it is in certain mid-western states, but it may cause much loss on individual fields. Near wilt (*Fusarium oxysporum* f. *pisi* race 2), on the other hand, may be common and destructive.

Affected plants may be dwarfed in size and have small rolled and distorted leaflets. Distinct wilting may or may not occur. The dwarfing, loss of foliage color, and browning of the water ducts in the stem are common symptoms. No conspicuous lesions are present, unlike the various root rot troubles.

With root rot, the fungus may enter the base of the stem above the cotyledons and destroy the tissues until the tap root is rotted away from the stem. This lesion usually is reddish brown and wedge-shaped. Yellowed or dead plants may occur either singly, scattered throughout the field, or in small patches. These diseased plants often stand out conspicuously because of their yellow color or dried upright foliage. Under high soil temperatures, the rot may not progress so rapidly, but the water ducts in the stem turn brown and the plant wilts. With favorable growing conditions, new roots may appear above the lesion and permit the development of at least a few pods.

The fungi have been found in the seed to a very slight extent. This apparently accounts for the spread of the diseases over wide areas. They are disseminated locally in infected pea straw, in contaminated soil, and in running water. The organisms spread slowly within a field, but after gaining entrance can remain alive for many years. If infected pea vines are perfectly ensilaged, the fungi are killed; but when the vines are placed in a stack, most of those on the outside do not undergo fermentation, and serve as a source of inoculum when hauled to the field for fertilizer.

Increase in soil moisture will accelerate the growth of the wilt *Fusarium*, but the most important environmental factor is the soil temperature. The

fungus does not grow at soil temperatures lower than 47°F. or higher than 85°F. and has for its optimum 70°F. to 72°F.

Control

Only general control measures are known. It is advisable to select well-drained soil that has not grown peas for at least four years. Contaminated pea straw should not be placed on fields where peas are to be grown. Burning pea straw in the fall is a questionable practice, for it is wasting much good green manure and is not eliminating stubble that may carry most of the inoculum. Since temperature is important, the peas should be planted early. Then the soil has less chance of becoming warm enough to favor infection until the plants are too large to be injured.

If the soil selected is low in humus, the growth of the plant can be hastened, and the consequent injury from root rot lessened, by applying fairly heavy applications of commercial fertilizers.

Recently a mid-season wrinkled pea variety, Delwiche Commando, and a canning variety, New Era, have been developed and released as being field-resistant to wilt and near wilt.

Root rots

Pea root rot (caused by *Aphanomyces euteiches*, *Pythium ultimum*, *Rhizoctonia*, and others) is a serious trouble in many sections where the crop is grown extensively. The various centers of infection are scattered throughout the field and gradually enlarge as the season advances. The disease causes a rotting of the roots and the parts of the stem that are below the surface of the ground. The diseased roots first appear water-soaked, then become soft and light brown or yellowish in color. Finally the outer layers of host tissue decay and slough off, leaving only the slender central core. If one of the affected plants is pulled up from soft soil, the central core of the tap-root and some of the larger side roots will pull out as a long string. This peculiarity, together with the color of the lesion, helps to differentiate root rot from wilt and from *Rhizoctonia* rot. Plants affected while still in the seedling stage usually lose their healthy color, slowly shrivel and die. If the plants are half grown or more when infection occurs and conditions are good for pea growth, there may be no symptoms of the trouble above ground. The plants may continue to grow normally and produce a crop.

Rhizoctonia is so common everywhere and affects so many plants that it is not surprising that under certain conditions it may cause serious trouble on peas. It mostly affects the base of the stem, where it causes a depressed reddish brown lesion that may or may not girdle the plant. It can be differentiated from *Fusarium* root rot in not producing a black or wedge-shaped lesion. It differs from the common root rot by not affecting the central core of the root which in root rot, can be pulled out like a long string. *Rhizoctonia* is common on many hosts but only certain strains affect peas. These overwinter in the soil and in crop refuse.

The other root rots are caused by several of the lower groups of fungi. If a diseased root is crushed and the tissue is placed under the microscope, hundreds of resting spores may be found. It is in this form that the fungus overwinters. In the spring these spores germinate either by a long fungous thread or by small spores that can swim about in soil water. These, together with the summer spores, are extensively abundant and can be carried by running water in the soil caused by splashing rain, as well as in diseased plant refuse. So far as is known, the fungus is never disseminated with the seed. When conditions are favorable and peas are grown successively on the same soil or in a short rotation, the pathogen grows luxuriantly.

The conditions most favorable for root rot are: a soil such as stiff clay or sandy soil underlaid with hardpan that holds water readily; plenty of rainfall; and fairly high temperatures.

Control

The general control measures are the same as those suggested for the *Fusarium* root rot (page 60). In the long rotations, however, one must keep in mind that the fungus also can attack vetch, alfalfa, sweet clover, and to some extent tomatoes, barley, and oats. The rotation should consist of such crops as corn, cabbage, timothy, and members of the onion family.

Early planting in well-drained soil is especially important in the control of root rot, for if the plants make half their growth before infection takes place, the crop will continue to develop satisfactorily. In many parts of the state the soil is much cooler and the possibility of rainfall is less during April than during May, June, and July.

If root rot once becomes generally distributed over a farm, other crops should be used for a few years or resistant varieties planted. Freezonian, Selkirk, and Resistant Thomas Laxton 251 are said to possess considerable resistance. Seed treatment also helps somewhat in retarding root rot infection.

Enation mosaic

Enation mosaic is perhaps the most serious of several virus diseases of peas in New York State. The first symptom is clearing of the veins in newly developed leaflets. Soon mottling and crinkling follow. Terminal growth is retarded, resulting in stunting. Enations or raised areas characteristically develop on the leaflets and pods accompanied by malformation of the pods. Aphids give most field transmission, although the virus can be spread by mechanical means. Barton and Schroeder at the New York State (Geneva) Agricultural Experiment Station are making excellent progress in developing canning varieties with resistance to this virus.

Control

Until resistant varieties become available, strict control of the aphid vector by use of insecticides is the only feasible measure.

PEPPER

Virus mosaic

Several viruses or combinations of viruses may attack peppers to cause a variety of foliage and fruit symptoms. Tobacco mosaic, cucumber mosaic, tobacco etch virus, spotted wilt, potato X virus, and possibly alfalfa mosaic are known to bother peppers. Of these, the first two are most important.

Tobacco mosaic virus causes a distinct mottling of the leaves as well as a stunting of the plants. Brown streaks often develop on the stems, accompanied by dropping of the leaves, blossoms, and fruits. Fruits on streaked plant stems that have dropped many leaves often are yellow and wrinkled. Certain virus strains may cause only a general yellowing of many leaves with slight stem streaking; however, one yellow strain causes a brilliant yellow leaf mottle.

The cucumber virus strain is the most common and destructive virus in peppers. It does not cause a distinct mottle of the foliage, but the infected leaves are narrow and a uniform grayish green. The plants are dwarfed and the blossoms either fail to develop or drop before the fruit forms. Some growers may blame low fertility or other cultural mistakes for the extreme stunting and poor color of their peppers. There is some evidence that this virus is seedborne. One strain of cucumber mosaic virus produces yellow rings on the leaves and fruits. On the latter, the spots are sunken and have concentric rings. In plants infected with the spotted wilt virus, a bright yellow mottle develops in the young leaves. The older leaves become bleached and drop. Fruits on such plants may have yellow-green circular spots, one-fourth inch in diameter, just below the surface of the green fruits. This gives a roughened or "orange peel" texture to the fruits. Thrips are the main vectors of spotted wilt, carrying the virus from nearby ornamentals and flowers to the young peppers.

Control

As in all virus diseases, control is based on prevention of infection. Transplants must be protected from sucking insects, aphids, and thrips, which might have contacted diseased tomatoes, cucumbers, celery, tobacco, wild ground cherries, horsenettle, milkweed, catnip, petunia, Jerusalem cherry, or Chinese lantern. After such contact the virus can be easily carried to young peppers. The perennials of this group should be removed from the vicinity of pepper fields. Since viruses can be transmitted merely by handling a diseased plant and then a healthy plant or by using tobacco while handling peppers, great care must be taken to minimize or prevent such transmission. Washing with soap removes virus from the hands.

Pepper fields should be as far removed as possible from cucumbers, melons, tomatoes, and celery because some of these viruses are usually present in these crops.

Regular applications of an insecticide effective against aphids will reduce secondary spread within a field.

The use of resistant varieties, such as Burlington, Yolo Wonder, Rutgers Worldbeater, Paul's Jersey Giant, Liberty Bell, or Keystone Giant, will give protection against the tobacco mosaic virus but not the cucumber virus.

Bacterial spot

Bacterial spot (*Xanthomonas vesicatoria*) affects both peppers and tomatoes causing a number of raised, brown spots on the underside of the leaves. When spots are numerous, the leaves turn yellow and drop. The symptoms are very conspicuous on the fruits; they appear as brown, cracked, rough spots. In wet weather other organisms enter the spots and cause the fruit to rot. The bacterial agent is carried on the seed and can overwinter in diseased refuse. Most infections begin in the seedbed from seed or refuse and are then carried to the field on transplants. There, further spread takes place by splashing rain, pickers, and other means.

Control

Use of the corrosive sublimate seed treatment is the most important measure in preventing initiation of spot in the seedbed. Antibiotic sprays have been used successfully to stop secondary spread, but seed treatment is more effective because it prevents the initial source of infection. One should use clean soil for growing transplants and choose fields free of peppers for several years to avoid the hazard of infection from diseased refuse. Field sprays are seldom needed or feasible; however, streptomycin or fixed copper could be used.

Anthrachnose

Anthrachnose (*Gloeosporium piperatum*) causes damage during hot moist weather by forming numerous dark circular spots on the green pepper fruits. These spots become covered with dark raised specks that are spore-carrying bodies of the fungus. During wet weather the spots are covered with pink spore masses. Rains splash the spores to other fruits which then become infected. The fungus penetrates the flesh and may enter the seed coat where it remains until the seed is planted. At that time the young seedling becomes infected.

Control of anthrachnose involves the use of corrosive sublimate seed treatment and several field applications of ziram, maneb, zineb, nabam, or captan.

Blossom end rot

Blossom end rot is a physiologic disease that occurs under the same conditions that produce it on tomatoes (page 82). Conditions are favorable when soil moisture becomes low after periods of high moisture and when rapid growth has occurred. Lack of water in the cells at the tip of the fruit causes large numbers of cells to die. This results in dry, black, sunken areas at the blossom end of the fruit. Secondary fungi may colonize these spots.

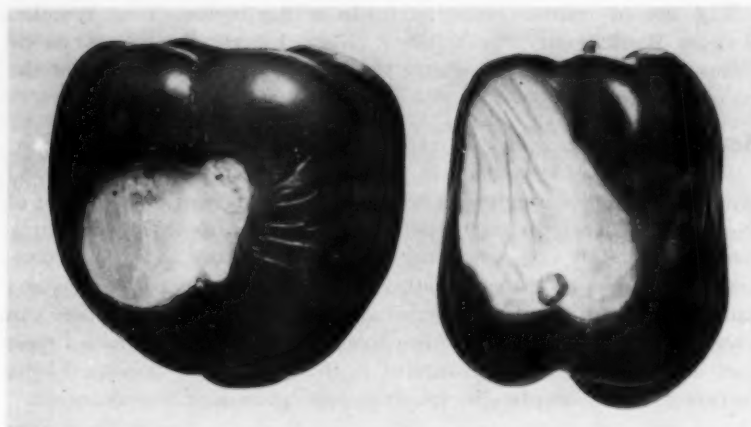


Figure 29. Pepper sunscald (U.S.D.A. Photo)

Control

Control involves the maintenance of an even water supply to the roots, especially during mid-summer mulching, using soil high in organic matter, and avoiding cultivation close to the plants.

Sunscald

Sunburning occurs when areas of the fruit exposed to direct sunlight develop irregular light colored spots that later become sunken and papery in texture. Secondary fungi may colonize such spots and cause decay. Defoliation by viruses or bacterial spot increases the prevalence of sunscald. Control of diseases, the maintenance of vigorous, healthy plants, and the use of heavy-vined varieties will minimize losses from sunscald.

RADISH

Downy mildew

Downy mildew (*Peronospora parasitica*) frequently causes a serious problem on greenhouse radish or in the early spring outdoor crop. The first symptoms include faded green areas on the upper leaf surfaces which later become yellow spots. Soon a heavy gray fuzz appears on both leaf surfaces, especially during cool wet periods. Not only are leaf surfaces destroyed, but the fleshy roots themselves become infected. Purple or brown discoloration extending from the shoulders downward and inward makes such radish unsalable. White radish varieties are especially susceptible.

Control

A rotation avoiding recent radish ground will be helpful in controlling mildew, since resting spores overwinter in old diseased tissues to cause

infection in the new crop. Planting the radish in well-drained soils with good air drainage to dry the leaves should be of value also. Repeated applications of maneb or Spergon every five days during mildew weather have also given effective control.

Black root

Black root (*Aphanomyces raphani*) is frequently serious on white or icicle radish. Red radish may be affected but usually shows much less injury. White Chinese winter radish is very resistant. The fungus enters through the tiny rootlets and gets into the main tap root where it causes black streaks. The normally white brittle root becomes blackened, constricted, and externally distorted. Late developing infections give only internal speckling but are unsalable. Mid-summer plantings growing during high soil temperatures are most affected. Low poorly drained spots in a field tend to favor the disease.

Control

Control of black root can only be achieved by soil chemical treatments with Vapam, VPM, Mylone, or formaldehyde. Good results have been obtained with these on Long Island.

RHUBARB

Leaf spot

Leaf spot (*Ascochyta rhei*) occurs in varying degrees in most rhubarb plantings but seldom becomes serious enough to warrant the use of fungicides. The first indications are numerous, tiny, greenish-yellow spots, somewhat resembling mosaic, on the upper surface of the leaf. Soon the spots turn brown, become variable in size and shape, and have a white spot in the center surrounded by a wide red zone that is bordered by a green zone. The dead tissue may drop out leaving a shot-hole effect.

Control

Best control for leaf spot involves a strict fall cleanup of infected leaves and stems followed by liberal use of fertilizer in the spring.

Crown rot

Crown rot (*Phytophthora parasitica*) frequently attacks individual rhubarb plants and kills them outright. The first symptom is the wilting of one or more leaf blades. Soon the leaf stalk loses turgidity, causing the entire leaf to fall to the ground. In some instances only a section of an old crown shows the disease at first. Later symptoms appear on the remainder of the stems. Tissues in the primary roots, in the buds, and in the lower ends of the leaf stalks have a brownish black discoloration.

Control

The fungus exists from one year to the next as mycelium in the diseased tissues or in resting spores; therefore, an exacting sanitation program should be followed involving the removal of all diseased plants even though certain crowns may appear to have individual healthy stems. When new roots are transplanted, every effort should be made to obtain them from healthy plantings. Soil fumigation with formaldehyde, vapam, chloropicrin, or methyl bromide is probably effective for preparing a new field but is too costly for a large field planting. For new plantings a soil should be chosen that has been free of weeds and has recently grown non-susceptible crops like onions, beets, corn, cereals, or grasses.

SPINACH

Downy mildew or blue mold

Downy mildew (*Peronospora spinaciae*) is prevalent wherever spinach is grown. It may be absent during certain seasons and then later destroy whole fields; or, by appearing year after year, it may constantly menace the crop.

The disease on the leaves appears as pale yellow spots. On the lower side the lesion is covered with a violet-gray mold. The affected part finally decays or dries, and the whole leaf dies. In severe attacks the entire plant is affected.

The fungus fruits abundantly on the underside of the leaf. The spores are splashed by rains and possibly blown by wind to other plants. Infection progresses at a rapid rate if the weather is favorable for the growth of the fungus. The leaves that are killed later may be filled with thick-walled resting spores that can overwinter. The following spring new infections come from the parasite living on winter spinach or harbored in the old diseased refuse as well as from the fungus that lives over in the seed.

For best germination the conidia or spores require a low temperature of 45°F. to 50°F. and plenty of moisture. After germination they prefer a higher temperature; therefore, mildew is most destructive during rainy periods when the nights are cool and the days rather warm.

Control

Practices that alleviate the mildew are two- or three-year rotations, plowing deeply all diseased plant refuse as soon as the crop is harvested, not crowding the plants too closely in the row, and planting the seed in well-drained soil. Where long rotations are practiced and no diseased crop is grown within several miles, the pathogen in and with the seed can be killed by treating the seed with hot water (see table 2).

Winter spinach harbors the mildew and furnishes the inoculum for the early spring crop. For this reason, winter spinach and early spring spinach should never be grown on the same farm.

Recently the new varieties, Early Hybrid 7 and Dixie Market, were

released. These are resistant to both mildew and blight. Both varieties are suitable only during cool periods for they bolt easily. Califlay is a new variety immune to mildew. When weather conditions are favorable for mildew, susceptible varieties should be sprayed with maneb every five to seven days.

Blight or yellows

Symptoms of blight (caused by the cucumber mosaic virus) begin with some mottling, as in other mosaics. Later there is a slight yellowing of the young inner leaves which changes to a bright yellow, and ends with the death of the plant. The disease gradually spreads to the outer leaves which, in turn, become yellow. During this time the foliage curls and wrinkles. If the plant is infected in the seedling stage, it remains much dwarfed. In the advanced stages of the disease, the plant dies.

The virus is transmitted from diseased to healthy plants by potato and spinach aphids. The disease appears within 12 to 30 days after the feeding of the contaminated insect.

The virus overwinters in the roots of perennials such as milkweed, catnip, mother-wort, ground cherry, phlox, plantain, hollyhock, burdock, wild bluebell, and white cockle. In the South aphids are capable of retaining the virus from one spinach crop to the next.

Control

In localities where blight is general, the only way to combat it is to use resistant spinach varieties. Virginia Savoy, Domino, Old Dominion, Dixie Market, and Early Hybrid 7 have such resistance. These should be planted instead of older varieties if the disease has been serious. Old Dominion stands the heat best, is not too soft for shipping, and if planted thinly will not seed too early. Spraying with fungicides or the use of seed treatment is of no value as a direct control measure. Spraying with insecticides to control aphid carriers is helpful, and the elimination of the weed hosts destroys the source of inoculum in the spring.

SWEET CORN

Smut

The smut of corn (*Ustilago maydis*) was probably present when white men first came to America. It is now present in nearly all countries where corn is grown and is of great economic importance in North America. Sweet corn is more susceptible than field corn and under very favorable conditions may become infected during the seedling stage.

The plant may be infected at any time in the early stages of its development but gradually grows less susceptible after the formation of the ear. Any part of the plant above ground can be invaded, although it is more common on the ears, the tassels and the nodes than it is on the leaves, the internodes and the aerial roots. The boil is composed of a white, smooth covering enclosing a great mass, sometimes four or five inches in



Figure 30. Corn smut (*Ustilago maydis*)

diameter, of black, greasy, or powdery spores. After the spores mature, the covering becomes dry and brittle, breaks open, and permits the black powdery contents to fall out.

The smut spores are blown long distances by the wind and are particularly prevalent when there is much dust in the air. They will germinate in rain water but germinate more readily in the drainings from barnyard manure. Consequently, spores are scattered over the farm with manure and have been known to pass through the digestive tracts of animals without losing germinating ability. The germ tube of the spore ordinarily does not enter the plant directly,

but a few drops of dew caught in the leaf sheath will remain long enough for the fungus to start a luxuriant growth. It is only when it is growing in this manner that it can enter the plant.

Hot, dry seasons are favorable for the growth of the fungus. When the soil is dry, dust can blow more readily, and it is by means of air-floating dust that the fungous spores are carried from one farm to another. Furthermore, with drought, the temperature usually is high, which is especially favorable for the germination of the spores. The spores, however, must have water collected in the silk, leaf blades, and other parts of the corn to permit the required amount of growth for penetrating the tissue.

Control

Seed treatment is of no value. Recommended control measures are rather unsatisfactory. If every grower in a given community would go through his field two or three times during the season and cut out all of the smut balls before they have time to break open, and destroy them by burial or fire, smut could be reduced. One year of cutting is not enough to cause a noticeable difference in the amount of the disease, but if this cutting is continued for two or more years, the smut will gradually be reduced. This is true, however, only if adjoining neighbors also cooperate. The removal of the smut should always be accompanied by rather long crop rotations.

Although there is some degree of resistance to smut among some of the newer varieties, in favorable hot dry summers the disease may be found in all varieties. The following have shown resistance in field trials at Geneva: Mellow Gold, Foremost Y 1, Evertender, Tenderblonde, Asgrow Golden 60, Golden Hybrid 2057, Prospector, Iochief, and Victory Golden.

Stewart's wilt (Bacterial wilt)

Stewart's wilt (*Bacterium stewartii*) was first found in the United States on Long Island in 1895 and now occurs wherever corn is grown. In New York its importance varies greatly from year to year. In favorable disease years, however, corn in the lower Hudson Valley and on Long Island is usually hardest hit. The periods of 1931 to 1933, 1947 to 1950, and 1952 to 1955 were severe years for Stewart's wilt. All of these crop seasons were preceded by winter months with relatively high mean temperatures that permitted large populations of the corn flea beetle (*Chaetocnema pulicaria*) vector to overwinter. The correlation of mean winter temperature with wilt prevalence has permitted actual predictions of disease severity to be made by geographic areas. When the averages of the mean temperatures of December, January, and February total 98 or greater in an area, the disease is likely to be present the following summer. The lower this figure, the less is the probability of Stewart's wilt occurring.

Sweet corn and popcorn are much more susceptible than dent corn; however, under very favorable conditions the latter may develop leaf streaks late in the season with little, if any, effect on yield.



Figure 31. Stewart's wilt of sweet corn (*Bacterium stewartii*)

Stewart's wilt makes its appearance at any stage of growth, but usually is most noticeable when the plants have reached a height of two to three feet. They are dwarfed; the tassel develops prematurely, whitens, and dies early; the leaves dry out one by one much as if frosted; and finally the stem dies and dries, but without soft rotting. A yellow slime ooze may collect on the surface of the inner husks. If the stem is cut off near the base and pressed, a similar yellow ooze collects at the cut ends of the "strings" in the stalk. This is the one means by which the disease can be differentiated from any other corn trouble.

It has been proved that the bacterium can live through the winter in the seed and in old diseased stalks. The bacteria can remain alive during the winter within the adult flea beetles (*Chaetocnema pulicaria*) which commonly feed on the young corn early in the spring; the pathogen is further disseminated by the twelve-spotted cucumber beetle (southern corn root maggot).

The organism is very susceptible to environmental conditions, especially since it must depend largely on the flea beetle for overwintering. If cold weather kills these insects, the source of local inoculum is nearly eliminated unless infected seed is planted. The amount of rainfall at planting time also has a great influence on the severity of infection. Heavy rain is especially favorable for the bacteria. In addition, the date of planting is important; the earlier the seed is planted, the more chance there seems to be for heavy infection.

Control

The principal measure for controlling wilt is that of preventing feeding on corn by the flea beetle vector. This is accomplished by well-timed applications of an insecticide, such as DDT. Predictions of wilt prevalence based on winter temperatures are made by Cornell pathologists and entomologists in cooperation with the United States Weather Bureau. These predictions are made available through the various county agricultural extension services. As the growing season begins and progresses, spray schedules are advised to fit beetle counts on a county or regional basis. Variety and planting date are other factors that determine the need for sprays. For susceptible varieties planted early and for areas having a moderate winter, a full program of four to six early sprays is recommended. For less susceptible varieties and for areas having a cold winter, perhaps none are needed. Suggested rates of DDT are two quarts of 25 percent emulsifiable concentrate per acre in eight to twelve gallons of water, using ground equipment; or three quarts in four to eight gallons of water per acre by aircraft. Dusts of five percent DDT also may be helpful. Timing should be based on beetle prevalence and varies from year to year.

Following warm winters and with early beetles present, the first spray should be applied when the corn breaks ground. Do not wait until the

first leaf flattens out. Following cold winters, the first spray may be delayed until the two-leaf stage. The timing of extra sprays depends upon weather and beetle counts; however, in some springs in the Hudson Valley, four to six applications at three- to four-day intervals are necessary for a high degree of control. In western New York on market corn, only two to four sprays five days apart are likely to be needed. On later processing corn in western New York, sprays are seldom necessary. Such need will be predicted through county agricultural agents. To avoid burning the leaves, a DDT formulation labeled for use on corn should be used. Application of dieldrin or heptachlor to corn soils has been tried by Dr. Adams in the Hudson Valley area. He indicates that in years predicted to have many flea beetles, either of these insecticides may be used to "spike" DDT in the first spray by using one-half pound (actual) per acre along with the DDT.

Other helpful controls include deep fall plowing, rotating corn as far as possible from old corn ground, using northern or western grown seed, delaying the planting date as long as practical, and using resistant or tolerant varieties. The following varieties have appeared to possess resistance to wilt in varying degrees: Sweetangold, Calumet, Golden Beauty, Golden Harvest, Golden 22, Golden 25, Golden 50, Iochief, Ioana, Seneca Super-Market, Seneca Beauty, Seneca Chief, Tenderblonde, Evertender, W. S. Golden Cross, Marcross, Barbecue, Hoosier Gold, F. M. Cross, Double Duty, Golden Jewel, Goldrush, Golden Security, Tendermost, Erie, Huron, and Victory Golden. Resistant popcorn varieties are South American and Sunburst.

TOMATO

Tomatoes are probably susceptible to more diseases than any other vegetable grown in New York. By adopting several control practices, however, growers will have no difficulty in producing high quality disease-free fruits. In New York, only early blight, anthracnose, and virus mosaic are of common importance. Certain other diseases appear sporadically, justifying discussion here.

The hot-water treatment is highly recommended in order to destroy seedborne bacterial spot, speck, and canker as well as the fungi causing early blight and anthracnose. (See page 85.) For protection against seed rot and damping-off, dust the seed with thiram.

Diseases Controlled by Foliage Fungicides

Early blight and Septoria leaf spot

Early blight (*Alternaria solani*) and Septoria leaf spot (*Septoria lycopersici*) may cause much damage to the foliage, and the *Alternaria* also may be responsible for a fruit rot. Early blight is caused by the same fungus that attacks potato foliage and is far more important than *Septoria* in



Figure 32. Early blight of tomato
(*Alternaria solani*)



Figure 33. Septoria leaf spot of tomato
(*Septoria lycopersici*)

New York. The latter rarely causes damage here unless the seed or plants have been infected in the south or tomatoes are grown repeatedly on the same ground.

Early blight is characterized by brown, irregular spots with concentric rings in a target pattern on the lower leaves. On old fruits, it sometimes may cause black, leathery, sunken spots near the stem end of the fruit. Septoria appears on the lower leaves as small, white-tan spots with tiny black specks in their centers. Both diseases will cause defoliation of the lower portions of the plant and expose the ripening fruits to the direct sun. This may result in sunscald and poor color. Spotting of the stems may occur with each disease under favorable moisture conditions. Alternaria also may cause collar rot and damping-off in young transplants.

Either fungus is carried in the old diseased plant refuse and will remain alive at least until the tomato stems and leaves are completely rotted. These fungi also may be carried on or in the seed; therefore, the hot-water seed treatment is necessary. Related weed hosts such as jimsonweed, horse-nettle, ground cherry, and nightshade, may keep these fungi alive in any field.

Both parasites grow best in wet weather and are aided in their dissemination by splashing rain. Both require a fairly high temperature. Alternaria spores germinate readily near 80°F., while Septoria has a range of 60°F. to 80°F. with the optimum at 75°F.

Control

In addition to field spraying (see page 75), the following general recommendations are offered: (1) plowing under all refuse directly after harvest, (2) using three-year or longer rotations with crops not belonging to the tomato family, (3) destruction of all weeds related to the tomato family growing in the field or within 50 feet of the field, (4) using great caution in growing or obtaining disease-free transplants, and (5) applying maneb fungicides in the field early and regularly. Two other important measures are hot-water seed treatment and spraying the plants in the seedbed with ziram or captan (two pounds per hundred gallons of water or two tablespoonfuls per gallon), alternated with fixed copper (one and one-half pounds metallic per 100 gallons of water or three tablespoonfuls per gallon).

A hand sprayer may be used in the seedbed or greenhouse. For larger areas, a small power sprayer is convenient. Applications should be made every five to seven days, beginning as soon as the plants break through the ground. The plant stems at the soil line must be thoroughly wet. Be sure the plants carry fungicide as they leave for the field.

The use of foliage fungicides in the field is very important and necessary for successful control of both of these diseases as well as for control of anthracnose and late blight (refer to page 75 for general tomato fungicide recommendations).

Anthracnose

Anthracnose (*Colletotrichum phomoides*) probably is the most serious disease of canning tomatoes. The loss results not only from the rotting of ripe fruit before and after picking but from the exceptionally high mold count in the canned product when only a small proportion of inconspicuously diseased fruits are present.

Anthracnose is a tomato fruit disease rather than a foliage or stem disease. In the earliest stages the lesions appear as small circular, sunken spots in the skin of the fruit much as though the surface had been indented with a matchhead or eraser. As these spots increase in size, the central portion becomes dark from the presence of black fungous structures just beneath the skin. Eventually the entire fruit becomes affected, often developing a watery rot into which various other organisms enter. Microscopic examination of the pulp beneath even the smallest spots often reveals the



Figure 34. Tomato Anthracnose
(*Colletotrichum phomoides*)

presence of the fungous spores in enormous numbers. Under proper conditions spores also may be produced in great numbers on the surface of the spots, giving a somewhat slimy tan or salmon colored appearance.

The fungus lives overwinter not only in old diseased vines but also on and in seed. In the seedbed and later in the field, spots that the casual observer would overlook entirely occur on the foliage and stems. The fungus becomes established in early blight spots and in flea beetle holes in the leaves. There it produces spores that later infect the fruits. Even though the fruiting is sparse on these infected areas, it enables the fungus to remain alive until fruits have formed. Green fruit may become infected, but the lesions do not develop until ripening begins. Although the fungus can enter uninjured fruit, infection is much more prevalent where there are insect stings or other breaks in the epidermis. When the fruit is ripe and the weather is favorable, spots develop all over the fruit and bear an innumerable mass of spores, each of which is capable of reproducing the fungus when it is splashed to other tomatoes or another area of the same fruit.

The pathogen will grow at temperatures of 55°F. to 95°F., but the optimum is 80°F. Therefore, when the temperatures are unusually high and the rainfall for August is excessive, there may be an epidemic of anthracnose.

Control

Control is based largely on the regular use of fungicides in the field. (See page 75.) Since the fungus multiplies rapidly in rotting ripe fruit, every effort must be made to pick and remove all ripe fruit from the field. A rotation free of tomatoes for three to four years also is helpful.

Late blight

Late blight (*Phytophthora infestans*) is a sporadic but disastrous disease of tomato and potato. Although it occurs to some degree on potatoes in New York almost every year, it attacks tomatoes only when environmental conditions are extremely favorable.

Irregular, greasy, gray, water-soaked patches appear first on the lower, older leaves. These spots enlarge rapidly and following rain or dew periods will develop a white downy growth in these spots on the undersides of the leaves. Under ideal conditions of poor air drainage, low night temperature, and moderately high daytime temperatures, leaf and stem tissues are killed and browned so rapidly that a field appears to be suddenly hit by frost. Both green and ripe fruits become infected rapidly, generally beginning in the area near the scar. The spots are brown corrugated areas with orange peel texture and a corky consistency underneath the skin. Margins are irregular but slightly sunken at the junction with healthy tissue. The white, downy growth may develop in these fruit spots.

Certain potato strains of this fungus cannot go directly to tomato but

must first pass several generations on potato. Other potato strains can go directly to tomato. The tomato strain can, however, infect potatoes and live overwinter in the tubers. The disease occurs each year on these crops in the southern United States and works its way northward as the crop culture progresses in this direction. In years when favorable weather exists for blight development and spread in the central Atlantic states as well as in New York, we can expect the disease to be present, and strict fungicidal measures must be undertaken.

Control

A regular spray program similar to that given below is the only sure method of reducing losses from late blight. Complete foliage coverage is very important. If late blight threatens, Bordeaux mixture or maneb are the most effective chemicals to use against it. Other measures such as wide separation of tomato and potato fields, rotation, and the use of disease-free transplants, should be utilized also.

Field Fungicides for the Control of Early Blight, Late Blight, and Anthracnose

For the successful production of high yields of disease-free tomatoes, a regular fungicidal program must be diligently employed. Recent advancements in the field of fungicides, application equipment, and knowledge of the disease organisms have given modern farmers the means for attaining excellent control of foliage and fruit diseases. In the field five or six applications of maneb (four pounds per acre) at seven-to-ten-day intervals will give good control if properly applied. Begin on mid-season or late varieties when the fruits of the first cluster are the size of walnuts and continue through the harvest season. On early varieties such as Fireball, Valiant, and Gem the first spray should go on immediately after first bloom.

If late blight should threaten in August during cool nights with heavy rainfall or dews and warm days, it is wise to substitute a Bordeaux spray (16-8-200) for it has longer lasting properties than maneb. Coverage and proper timing are very important aspects of tomato disease control. With hydraulic sprayers comparable results have been obtained with 100 and 200 gallons per acre. Below 100 gallons coverage becomes a limiting factor except for the earliest applications. Concentrate sprays and mist blowers using 50 gallons per acre are being used successfully where disease potential is moderate and extreme care is used in application. Spraying is, in general, more effective, gives better coverage, lasts longer on the plant, and is cheaper than dusting. It should be used if at all possible. However, if dusts must be used, freshly mixed maneb should be applied, using 35 pounds per acre.

Diseases Not Controlled by Foliage Fungicides

Verticillium wilt

The fungus, *Verticillium alboatrum*, is widely present in New York soils because of its ability to attack a wide range of hosts including many vegetables, such as tomato, pepper, potato, eggplant and melons. It can live in the soil for a number of years following the growth of a susceptible crop.

On tomato the chief symptom of wilt is the development of yellowish splotches on the older leaves in the center of the plant. Soon after, chocolate-brown spots develop in the middle of the yellow areas. At the same time the plants drop some of their leaves starting at the bottom of the plant. Mid-day wilting is also common. Upon careful inspection of the underground stem, tan streaks in the vascular system from which *Verticillium* may be cultured will be noted.

Control

Control of *Verticillium* is difficult because of its ability to survive in the soil for years and because its internal nature makes it immune to fungicides. Pathologists and plant breeders are developing resistant varieties and have already introduced Loren Blood, Moscow, Simi, Pearson VF 6, Pearson VF 11, Red Top V 9, and Geneva 11. The first five are not well adapted to the east; however, Red Top V 9 and Geneva 11 do very well and are highly recommended.

Fusarium wilt

Fusarium wilt is of considerable importance in the greenhouse and on Long Island but of minor importance upstate. The causal fungus, *Fusarium oxysporum* f. *lycopersici*, can persist in the soil for many years but causes infection only when soil temperatures are 80°F. to 90°F. This accounts for its being a minor disease upstate. It causes serious losses in the southern and western states where high soil temperatures are prevalent.

Fusarium causes a true vascular wilt, the first symptom of which is a yellowing of the lower, older leaves on a single stem. These leaves soon die as do others, progressing from the base of the stem outward. Soon the top portions are affected; they too yellow, wilt, and die. Infection occurs through the root hairs, goes into the vascular system, and eventually reaches the extremities of the plant. Internal examination of the stem will disclose a brown discoloration in the vascular area, generally extending the full height of the stem.

Control

Considerable progress has been made in the development of *Fusarium* wilt-resistant varieties suitable for outdoor as well as indoor culture. These offer the best method of control. The following include most of the

presently available outdoor varieties: Brookston, Pan America, Kokomo, Tipton, Boone, Jefferson, Homestead, Kopia, Chesapeake, Golden Sphere, Sunray, Roma (paste), Red Top V 9 (paste), Manahill, Manasota, Marvana, Manalucie, Grothen's Globe W R, Garden State, Alamo, Texto 2, Wiltmaster, Tippecanoe, and Indian River.

Leaf mold

Few greenhouse tomatoes entirely escape the presence of the leaf mold fungus (*Cladosporium fulvum*), but the disease is of no importance in the field. Early symptoms include light yellow spots on the upper side of the leaf. On the corresponding lower side, greenish or purple mold soon appears. Finally the leaf tissue dies and the leaf curls up and drops. The mold is seldom found on the stem and is difficult to detect on the fruit.

The fungus lives over the winter in the seed and in the old diseased plant parts that are not destroyed at the end of the season. The parasite is splashed from plant to plant during watering and also may be carried by insects. The mold is very sensitive to dryness, and this in turn is determined largely by the light and the temperature in the greenhouse. The fungus grows best at 55°F. to 70°F. when the soil or the air contains much water. Consequently, the disease is present in greatest abundance where the greenhouse is cool and not well ventilated.

Control

Since the disease must depend for growth on an almost completely saturated air, one of the control measures is to keep humidity in the greenhouse too low for growth of the fungus. Some of the steps in obtaining this condition are: to wet the plants as little as possible when watering the soil, to keep the ventilators partially open when heat is on, to avoid shading, and to set the plants far enough apart so that air can circulate freely among them.

Installation of fans to move otherwise stagnant air has been very useful in some greenhouses. The dry, warm air is drawn into the house and the waterladen air is expelled. This movement takes care of the immense amount of water given off by large tomato plants. Air moving at only one-half mile an hour has twice the evaporating power of still air. In addition, fans eliminate air pockets that are present even though the ventilators are wide open.

If no fans are available, fairly satisfactory results can be obtained by having continuous ventilator openings both at the top of the house and along both sides near the ground. If the plants are set in crosswise rows the air currents can follow down the row, and the exchange of air will progress rapidly. This can be facilitated also by planting two rows close together and the next two rows farther apart. This will permit the usual number of plants in a given space and at the same time will give the air currents wider unobstructed lanes through which to move.

If the mold is present during cold weather, lowering the night tem-

perature of the house to 50°F. for several nights in succession checks the growth of the parasite. Lowering of the temperature should be practiced as much as good growth of the plants will permit.

The resistant varieties, Bay State and Vetomold, are satisfactory where only one strain of the fungus is present. In most greenhouses, however, one or more additional strains have become established so that the newer varieties, Improved Vetomold, Improved Bay State, or Waltham Mold Proof Forcing, are required. Other resistant varieties include Manalucie, Vinequeen, Vagabond, and Globelle.

Spraying at weekly intervals with maneb, ziram, or ferbam, two pounds in 100 gallons of water, has given commercial control both in the greenhouse and in the field. Applications should be begun when the plants are only half grown and the spray should be directed to all parts of the plant, especially to the lower surface of the foliage.

Virus diseases

Tomato mosaic is a serious trouble in most of the older tomato growing districts. The virus causing the disease is the same as the one in tobacco and many other closely related plants, not only among the cultivated crops but also among some of our very common weeds. With common tomato mosaic, the leaves are mottled with yellow and green, and their surfaces are roughened. The yellow areas may die and turn brown. Affected plants are dwarfed and usually bear few fruits although the amount of blossoming may be normal. Occasionally the fruit is affected with russetting, with streaking, or with raised blotches. Plants badly affected in the seedbed may die when set into the field. Field infection never causes death.

Since several strains of the tomato virus (TMV) are known, varying degrees of yellowing and stunting of the plant and russetting of the fruit may be expected depending upon which strain is present.

Tomato mosaic virus is carried by aphids and other sucking insects and can live in the soil and seed for at least four months. It overwinters in the roots of ground cherry, horsenettle, jimson weed, nightshade, bitter-sweet, matrimony vine, and other related plants.

Cucumber mosaic on tomato is spectacular in that shoestring or filiform leaves develop resembling severe 2,4-D injury. The leaflets near the top of the plant are most conspicuously affected, often consisting of little more than a central ribe. If young plants are infected, they become very stunted. These plants set only a few small fruits.

Cucumber mosaic may occur wherever tomatoes are grown but seldom in as many plants in any one field as tomato mosaic. This is true because the cucumber virus is not easily transmitted mechanically, does not withstand drying, and will not persist in the soil. Most spread is by aphids that carry the virus from infected weed hosts to the young tomato plants.

The cucumber virus lives in the roots of weeds and flowers, especially milkweed, catnip, mother-wort, white cockle, burdock, flowering spurge, pokeberry, ground cherry, plantain, phlox, hollyhock, and wild bluebell.

Streak is merely another form of mosaic. Dead areas form in the leaves, especially along the veins, and brown streaks appear on the petioles. Light brown, sunken spots variable in size may be found on the fruit. In severe cases the whole plant dies.

One kind of streak (double virus) can be produced by inoculating the tomato plant with both tomato mosaic virus and potato x virus. When the two viruses are together, they seem to be more virulent and to kill at least parts of the plants. A second type is produced by a combination of tomato and cucumber mosaic viruses on the same plant. In fact, any other host mosaic that is able to pass over to the tomato seems to cause the disease known as streak when it mingles in the plant sap with the ordinary tomato mosaic. There is also a single virus streak, but it is very rare in New York, if present at all.

Spotted wilt is another virus disease that may be found in greenhouse tomatoes or in those grown in home gardens adjacent to certain ornamentals and flowers. This virus causes a bronzing of the leaves produced by numerous, tiny, dead spots on the young top leaves. The tips of the stems show dark streaks and the growing points wither. Ripe fruit symp-



Figure 35. Cucumber mosaic on tomato

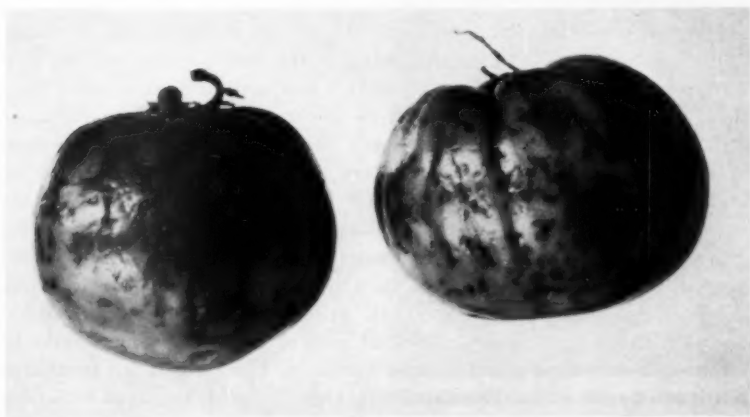


Figure 36. Double virus streak of tomato

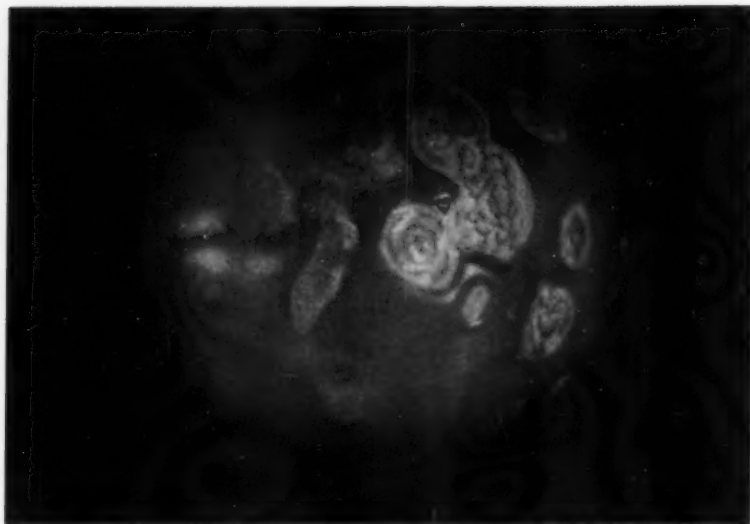


Figure 37. Spotted wilt on tomato

toms are spectacular—numerous large spots consisting of alternate concentric rings of yellow and red are produced. A slight sinking of the tissues around the margins of the affected area causes the center of the ring to appear raised. A definite ridging or roughening also may develop in the shoulder area of the fruits.

The spotted wilt virus is transmitted only by thrips that pick up the virus from infected flowers, ornamentals, lettuce, celery, spinach, potatoes, peppers, mallow, and jimson weed. Dahlias, calla lilies, nasturtiums, petunias, and zinnias are especially likely to carry the virus. These should be well isolated from tomatoes.

Internal browning, sometimes called graywall or brownwall, is exhibited as a darkening between the lining of the seed cavities and the skin of ripe or green fruits. Usually no surface symptoms are noted other than the gray color showing through from the inner lining. Such fruits are always produced on sturdy, apparently healthy plants, showing no signs of mosaic or mottling. Several factors have been demonstrated to be capable of producing these symptoms; however, Boyle of Pennsylvania has experimentally reproduced the disease by introducing certain strains of tobacco mosaic into healthy plants just as fruits are setting. This appears to be a shock phenomenon. This experiment is certainly strong evidence that certain virus strains are at least one cause of the disorder. Plantain is the most important weed host of this strain and should be removed from the neighborhood of tomatoes. The virus is not seedborne but it can be transmitted mechanically. Other possible causes of browning include unbalance of the phosphate-potash ratio (potash deficiency), sud-

den fluctuations in growing temperatures, and continuous culture below 70°F. in wet soils. No practical control has been suggested other than to eliminate plaintain weeds, grow plants at temperatures above 70°F., and use well-drained soils with adequate fertility.

Control of Tomato Virus Diseases

The most important control measure is the eradication of weed hosts in or near the tomato field and greenhouse, especially those adjacent to the seedbed. In addition, no flowers or ornamentals should be grown in the same greenhouse with tomato seedlings. This is very important. Among the more common flower, weed, and other hosts of the viruses on tomatoes are catnip, mother-wort, and certain other mints, bur and wild cucumber, ground cherry, horsenettle, milkweed, burdock, mallow, petunia, pokeweed, calla lily, chickweed, Chinese lantern, chrysanthemum, wild bluebell, flowering spurge, white cockle, dahlia, galinsoga, Jerusalem cherry, sweet pea, jimson weed, nightshade, plantain, tobacco, and potato.

If young plants are kept healthy, a fairly large plant may develop before the influence of the disease can reduce the yield very much. In the greenhouse it is also important to avoid all tomato refuse in the seedbed and to remove any mature living tomato plants from the greenhouse where young plants are being grown. Since the virus of tobacco mosaic can live in the soil for short periods, the seedbed or a new crop in the greenhouse should not be planted for at least four months after the old crop has been removed.

The tomato virus can live for a long time in natural leaf tobacco and frequently is spread to tomato seedlings from cigarette butts or when workmen use chewing tobacco, cigarettes, and cigars while handling tomatoes. Workmen should wash their hands in soapy water after using tobacco and before handling tomatoes. In greenhouses, tomato mosaic is also spread on knives during pruning operations; breaking out the undesirable shoots affords less chance of contamination than does cutting.



**Figure 38. Catnip (*Nepeta cataria*)
a common virus host**

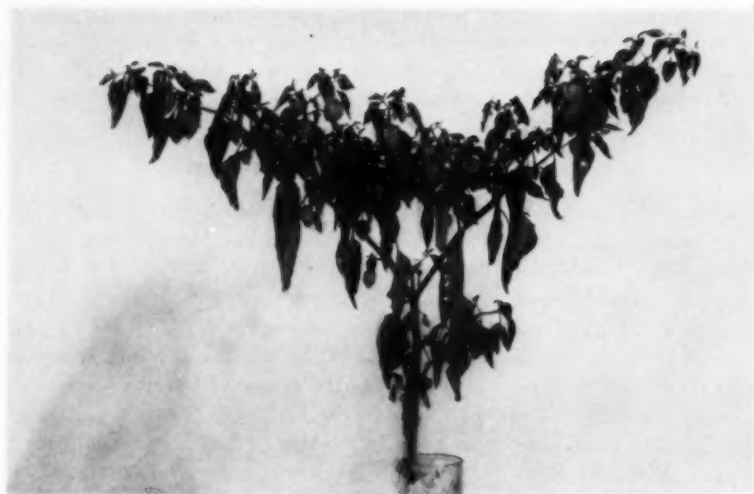


Figure 39. Ground cherry (*Physalis* sp.)

Heavy applications of potash fertilizer in relation to superphosphate seem helpful in reducing mosaic injury.

Seed treatments and foliage fungicides are not effective in controlling any of these virus diseases.

Blossom end rot

Blossom end rot, a physiologic disease whose basic cause is lack of adequate soil moisture, is costly to many tomato growers. A lack of calcium uptake from the soil to the fruits during dry weather has been shown to be responsible for the disease. Research by Geraldson in Florida indicates that excessive magnesium, potassium, sodium, or ammonium salts or a deficiency of soluble calcium salts cause a decreased calcium uptake and increase the disease. Rapid early growth accentuates the problem because it tends to increase the calcium requirement per unit of time.

The first symptom of rot is a slight water-soaked area near the blossom end of the fruit. The lesion soon darkens and enlarges in a constantly widening circle until the fruit begins to ripen. The decaying spot may be merely a speck or it may involve half or even more of the tomato. Although a sudden lack of water is the principal cause of blossom end rot, excessive soil moisture may smother the root hairs and cause the rot to occur during sudden hot weather. It may be more serious on the windward than on the leeward side of a field.

Control

Since blossom end rot is so closely related to the water supply, an important control is to regulate the moisture supply in the soil. The land

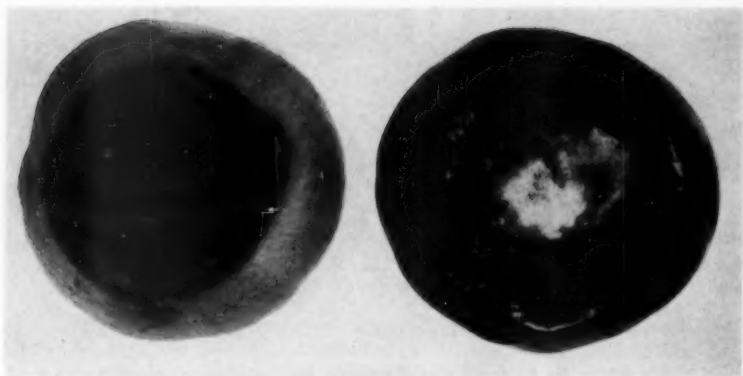


Figure 40. Blossom-end rot of tomato (Physiological)

should be well drained during a dry period. If drought occurs, cultivation should be very shallow to reduce water loss. Hoeing or cultivating should be done no closer than one foot from the plants to avoid root pruning. Liberal amounts of fertilizer high in superphosphate should be used (1-3-1 ratio).

In the greenhouse, young plants should not be grown too quickly nor should the plants be subjected to severe hardening before transplanting. A steady growth rate as a seedling and as a field plant will discourage much of this trouble.

If irrigation of any kind can be used, it may prove profitable when hot, drying winds are blowing. Mulching, which serves to maintain an even level of soil moisture, should be practiced where feasible. Tomatoes planted unusually early while the soil is still cold are likely to have the first fruits affected by blossom end rot. Consequently, a delay in planting helps to reduce the problem.

Good results have been reported in Florida by spraying with calcium chloride (four pounds per 100 gallons per acre) several times during the period of most rapid growth. Application in the same tank with fungicides within 24 to 48 hours after heavy leaching rains were useful. This places calcium directly where it is needed in the fruits.

Bacterial diseases

Bacterial spot (*Xanthomonas vesicatoria*) may become serious on tomato and pepper during warm seasons. Although seedlings may be attacked, the most serious losses are on the fruit, which is disfigured. The young lesions on the fruit are dark raised spots, usually with a narrow water-soaked border. The older lesions are black and elevated with irregularly lobed margins. The center of the lesion becomes slightly sunken, brown, and corky and usually does not penetrate very deeply into the pulp of the tomato. The symptoms on the leaves are not so



Figure 41. Bacterial spot of tomato (*Xanthomonas vesicatoria*)

noticeable as on the fruit. At first the leaf spots are very small, water-soaked, and translucent. Later they enlarge, turn black in the center, and become sunken on the lower side of the leaf. Severely infected leaves turn yellow and finally become brown and dry. Early infections may cause blossom blasting and dropping. The tomato strain can always infect peppers, but the strain from peppers does not always infect tomatoes. Spread in the field is caused largely by wind-blown rain and equipment.

Bacterial speck (*Pseudomonas punctulans*) is another bacterial disease of fruits closely resembling spot in its symptoms. It has the same life history and control measures. Speck causes numerous tiny dark brown, slightly raised spots on the fruit. These spots are less than one-sixteenth of an inch in diameter. They have definite margins and do not extend deeply into the fruit. The causal bacteria affect only tomato, not pepper. Only young fruits are susceptible, and wounds are not necessary for infection.

Bacterial canker (*Corynebacterium michiganense*) is a very minor disease in New York because of the widespread use of hot-water treated seed. The first symptoms are wilting, rolling, and browning of the leaves on one side of the plant. The pith may disappear or become discolored. In severe cases the whole plant dies. When the soil is infested, the fruit becomes infected and shows "bird's-eye" spots.

Bacterial canker may become complicated by the presence of other bacterial organisms in the diseased tissue. The canker organism inhabits primarily the food-conducting tissues of the plant; later by collapsing these tissues it may extend into the pith, or through cracks of the stem to the outside of the plant. Bacteria overwinter on the seed and in the old diseased plant refuse.

Control of Bacterial Diseases

The use of hot-water treated seed is the foundation of successful control. The wide adoption of this practice is responsible for the rarity of

tomato bacterial diseases in New York. Imported southern transplants should be certified as being free of these diseases, for they can be important sources of early infection. Once established in a crop, the bacteria can live free in the soil for at least one year; therefore, rotation is important. Tomatoes should be grown on soils free of tomatoes for the previous two to three years.

Early field infections can be stopped from spreading by spraying with fixed copper (two pounds metallic) added to the regular maneb suspension that is needed for early blight and anthracnose protection. In this combination maneb may be reduced to two pounds in 100 gallons.

Seed Treatment Needs and Methods

Proper seed treatment is the basis for control of many very important vegetable diseases. Two general types of treatments, eradivative and protective, are employed; both are based on the location of the disease organisms in or on the seed. Eradivative treatments require hot-water or mercuric chloride soaks in order to kill organisms deep inside the seed or under the seed coat. Protective treatments with milder chemicals used as a coating provide the seed with early protection against soil fungi that are capable of rotting or weakening the seed. The heat or chemical soak treatments do not leave protective coatings on the seed; therefore, dusts or slurries should be used before planting.

Hot-Water Method

Several progressive seed houses now offer seed already hot-water treated. However, you can treat seed on the farm as follows: A loosely woven bag, or bags (such as cheesecloth), are half filled with seed. A large tub or similar container is partially filled with hot water at about 122°F. Facilities for maintaining and reading this temperature must be provided. A supply of hot and cold tap water is very satisfactory, or an external source of heat on the container and a cold tap can be used. Accuracy in recording and holding this temperature is most important. If the temperature falls below 122°F., the organisms may not be killed; if it goes much above this figure, seed germination may be lowered. Dairy or laboratory thermometers are very good, but most household models are not sufficiently accurate. Stirring or some other method of agitating the water is necessary to maintain uniform heat throughout. With lightweight seed, metal or rock weights can be placed in the bags to keep the seeds under water. After soaking for the proper time intervals (generally 25 minutes, refer to table 00), remove bags from the water and immediately spread the seed out to dry at normal room temperatures (70°F. to 75°F.). After drying, the seeds may be stored further or planted immediately. Fresh, vigorous seeds however, withstand the heat treatment better than one- or two-year old seed and should be treated shortly after harvest whenever possible. Sometime before planting, a dust treatment with thiram or captan should be applied for seed rot protection.

Mercuric Chloride Method

This treatment is very useful on cucurbit and pepper seed for killing organisms on the seed surface. Seeds are tied loosely in a cheesecloth or loose-meshed bag and dipped for five minutes in a mercury solution. This is made up by dissolving one ounce of mercuric chloride in a little hot water and then adding enough cold water to make the necessary total volume. A stone or glass container should be used, for mercury is corrosive on metals. Final temperature should be between 60°F. and 80°F. The chemical can be purchased in a drug store as a blue powder or in coffin-shaped tablets. One of these tablets in one pint of water or one ounce of the powder in seven and one-half gallons of water makes a 1 to 1,000 solution. Use at least one gallon of solution for each pound of seed. Please refer to table 2 for recommended solutions. After the five-minute soak, the bags of seeds are drained and *must be washed thoroughly and repeatedly for five to ten minutes* in running fresh water to remove all traces of mercury. **This is very important.** The seeds are then spread out in a thin layer to dry. This chemical is a **deadly poison** to humans and animals and must be kept out of their reach and carefully disposed of when the treatment is completed.

Dust-On Method

A chemical "overcoat" is easily applied to the seed and gives needed seed rot protection. Thiram, captan, Phygon, or Spergon may be used any time before planting. Dusts are distributed over the seeds by shaking the packets with a small amount of the chemical. For larger seed lots a jar or can may be utilized. The amount needed varies with the chemical and the seed, so follow label recommendations. In recent years combinations containing an insecticide and fungicide have been prepared for joint protection against soil insects and seed rot. These combinations are strongly recommended on sweet corn, bean, lima bean, pea, carrot, squash, cucumber, pumpkin, and melon seed.

Seedling Damping-off and Its Control

Several fungous genera may attack seedlings at or near the soil line where moisture and temperature conditions are ideal. These include *Fusarium*, *Pythium*, *Rhizoctonia*, *Thielavia*, *Botrytis*, and *Phytophthora*. Stems of diseased plants become weakened at the soil line and wilt or topple over, resulting in outright loss of the plant or production of a weak wirestem seedling. When conditions are favorable for its development damping-off may be troublesome in coldframes and outdoor seedbeds as well as in greenhouse flats.

Seed treatments have little or no effect against this problem. Satisfactory control comes only from employing several proven principles of good plant culture along with certain chemical soil treatments. These include (1) the use of light, well-drained soils free of pathogens, (2) careful control of the environmental factors of moisture, light, and relative humidity, and (3) wise use of soil drenches and foliage sprays.

Old vegetable soils generally contain disease-producing fungi and should be composted three to four years if it is necessary to use them. Pasture soils or those from non-vegetable fields are ideal. If these types are not available, then soil steaming or chemical treating may be necessary (refer to page 90). The soluble salts content should be sufficiently low before planting to avoid burning the tender seedlings later.

After planting, the soil should be watered as little as is compatible with good growth until after the seedlings have hardened off and are beyond the danger stage. Damping-off becomes troublesome only when plants and soils are overwatered, excessively shaded, and permitted to remain wet for long periods. Crowding of plants in the bed or flat, and wide fluctuations in house temperatures add to the difficulties. Keep relative humidity as low as feasible by opening the ventilators whenever steam is on. Open ventilators also maintain slight movement of the air through and around the plants. Water only in the morning of a sunny day. Heavy watering at long intervals is more desirable than frequent light sprinklings. Fix all broken panes on sash to avoid drip and wet spots.

In greenhouses or coldframes where damping-off, wirestem, drop, or Botrytis gray mold have been troublesome, soil chemicals should be used. Certain fungicides or combinations worked into the upper soil layers before seeding or watering the soil have proved very useful. Tomatoes, peppers, eggplant, lettuce, and cauliflower have responded especially well.

For cabbage, cauliflower, broccoli, and lettuce

Pre-planting soil treatment: Where wirestem is the only problem and no club root or weeds are present, the use of a mixture of Terraclor and captan tilled dry into the top four inches of soil has given good control of Rhizoctonia wirestem and Pythium damping-off. In addition, root systems are more extensive and free of external browning. One cup each of Terraclor 20 and captan 7½ are mixed and spread over 100 square feet of bed (37 pounds actual Terraclor and 14 pounds actual captan per acre). Planting may follow immediately after rototilling. For lettuce, endive, and escarole *one-half* strength materials must be used to avoid stunting.

Post-planting drench: Terraclor 75 and captan 50 may be watered into the soil after planting instead of treating soil before planting. One-half pound each of Terraclor 75 and captan 50 are added to 100 gallons of water and five gallons of this suspension is applied over 100 square feet of bed. A sprinkling can or hose proportioner is useful for this purpose. After emergence and cultivation another application of these materials as a spray is helpful. Here the volume can be reduced, using only enough to thoroughly wet the stems. Use of the older materials, calomel or mercuric chloride, may still have a place, although these are more apt to cause injury.

Calomel (eight ounces in 50 gallons of water) or mercuric chloride (three and one-half ounces in 50 gallons) is poured along the base of cabbage, cauliflower, or broccoli stems, using one pint on four feet of

Table 2. Seed Treatment Methods and Duration.

<i>Crop Seed</i>	<i>Method or Chemical</i>	<i>Temperature Dilution or Duration</i>	<i>Controls</i>
Asparagus	Calomel (Calogreen)	4 ounces mixed with 1 lb. seed	Damping-off
Bean, lima bean, carrot, pea, sweet corn	Combination fungicide- insecticide	Manufacturer's recommendation	Damping-off Seed-rot Maggot
Beet	Phygon, thiram or captan	Manufacturer's recommendation	Damping-off Seed-rot
Cabbage and Brussels sprouts	Hot water later captan or thiram	122° F. for 25 min. Dry, then dust with fungicide	Black-leg Black-rot Alternaria Seed-rot
Cauliflower and Broccoli	Hot water later captan or thiram	122° F. for 20 min. Dry, then dust with fungicide	Black-leg Black-rot Alternaria Seed-rot
Celery	Hot water	118° F. for 30 min.	Early blight Late blight
Celery	Calomel (Calogreen)	1 ounce per gallon of water; soak seed until thoroughly wet	Damping-off Seed-rot
Eggplant	Hot water later thiram, captan or Semesan	122° F. for 25 min. Dry, then dust with fungicide	Phomopsis Seed-rot Damping-off
Melon, cucumber, pumpkin, squash	Mercuric chloride later combination fungi- cide-insecticide	1-1,000 for 5 min. Dry, then dust with combination	Anthraco- nose Scab Angular leaf- spot Seed-rot
Pepper	Mercuric chloride later thiram or captan	1-3,000 for 5 min. Dry, then dust with fungicide	Bacterial spot Seed-rot Damping-off
Spinach	Phygon, thiram or, captan	Manufacturer's recommendation	Damping-off Seed-rot
Tomato	Hot water later thiram	122° F. for 25 min. Dry then dust with fungicide	Bacterial spot Bacterial speck Anthraco- nose Early blight Seed-rot Damping-off

row. These chemicals will control maggots as well as wirestem, and if used, the Terraclor-captan method is unnecessary.

For tomatoes, peppers, and eggplant

Post-planting drench: The addition of captan 50 to the first water used on the flats after seeding gives good protection against seed rot and damping-off and will increase stands by about 20 percent. Use one table-

spoonful per gallon or one pound per 100 gallons of water, and apply five gallons over each 100 square feet of surface.

Foliage spray: For added protection against damping-off, weekly sprays of captan 50 (two pounds per 100 gallons or two tablespoonfuls per gallon) are useful. Apply sufficiently to wet the plants and run down the stems. Avoid high pressure on the tender plants. Size of sprayer will vary with the plant bed areas. Knapsack and midget power sprayers that can be moved easily between benches are good.

Nematodes

The concept of eelworms in the soil feeding on the roots of vegetables may be difficult to understand, since most pests can be seen on the plant above ground. These pests are present, however, and are becoming more serious each year in muck soils as well as upland soils.

Nematodes are tiny eelworms about one-fiftieth of an inch in length, with the diameter of a horsehair. They have digestive, nervous, sexual, and excretory systems, but no circulatory or respiratory systems have been found. Many kinds or species are known in the world, but only seven are of importance in New York; of these, only the root knot and bulb nematodes are considered of importance on vegetables.

Root knot nematodes

Meloidogyne sp. are by far the most widespread and serious type of nematode attacking vegetables. Once present in a soil, and with favorable soil temperatures (80°F. to 85°F.) they will multiply on susceptible crops. One female may lay from 500 to 1,000 eggs and a life cycle can be completed in 24 days. The young, newly hatched larva swims to a root tip, enters, and becomes established inside. There it feeds on sap and injects a substance that stimulates the plant cells to divide and enlarge rapidly, forming a gall or knot. The nematode's life cycle is completed in the root at the expense of the plant. Nematodes seldom kill a plant, but they severely reduce its yield and quality. This injury varies with the crop, species, and time of infestation. Among the most seriously affected vegetables in New York are: carrots, lettuce, celery, onions, and tomatoes. Other vegetables susceptible, but of lesser



Figure 42. Root knot nematode on lettuce

affected acreage, are cucumber, melon, squash, pumpkin, eggplant, spinach, parsley, fennel, parsnip, and celeriac. Less susceptible crops are beet, asparagus, cabbage, cauliflower, turnip, radish, pea, bean, and potato. Most cereals and other grasses are nearly immune.

The nematodes lie dormant below a soil temperature of 57°F., and winter temperature fluctuations have a bearing on the numbers overwintering. In winters when the soils freeze and thaw several times, the number of nematodes is greatly reduced. The problem is more common in loose, sandy soil or muck than in clay or heavy loam soils.

Control of root knot nematodes may be accomplished by using rotation to starve the pests with non-susceptible crops, or by applying soil fumigants. Two successive years of resistant crops such as cereals, including corn, grasses, potatoes, cabbage, or beets, will reduce the population greatly. It is better in these two years to grow some crop from seed planted directly into the field to avoid carrying the pests from the greenhouse or hotbed into the field on plants. Early planting with short season crops will avoid injury before nematodes become very active.

In the greenhouse it is economically feasible to use chemicals to kill the nematodes. Ethylene dibromide, methyl bromide, D-D, or Telone are effective against nematodes, and heat, steam, chloropicrin, Mylone, or Vapam have the added advantage of killing most soil fungi (see chemical soil treatments below).

Outdoors the use of fumigants is the most practical and certain control for nematodes. Three types of chemicals with differing methods of application are available. For details on their proper usage, refer to page 92.

Bulb nematode (Bloat)

Bulb nematode (*Ditylenchus dipsaci*) attacks only onions and garlic among the vegetables. In New York it is known only in mucklands and has been a problem only where set onions are used (Orange and Madison counties). Sets are the most common mode of introducing the pest into an area, but once present, the nematodes will attack onions planted from seed. (See page 55 for description and control.)

Soil Chemical Treatments

A wide range of chemicals for applying to or under the soil has been developed to control fungi, nematodes, soil insects and weed seeds. This is a rapidly expanding phase of agricultural research and involves detailed work on equipment, formulation, and plant toxicity. Great progress has been made but much is yet to be learned. This discussion will attempt to outline uses for presently available and feasible chemicals, and to describe their properties and attributes.

Three types of chemicals differing in their formulation and method of application, are available, i.e. (1) liquids, (2) gases under pressure, and (3) wettable powders or dusts. The choice of the most suitable material must

be based on size of area to be treated, pests needing control, value of crops to be protected, and available equipment. Some chemicals will kill only nematodes, others only fungi, but some will kill both of these pests, as well as soil insects and weed seeds. Cost of the chemical is roughly in proportion to these abilities. Consequently, by knowing the pests at hand and choosing the proper chemical, costs can be minimized.

Liquids

Formaldehyde, a 37 percent solution in water, can be further diluted and used as a soil drench against fungi and soil insects, but is weak against nematodes and weed seeds. Dilute one gallon in 49 gallons of water and apply two quarts per square foot of soil. Treat potting soil by mixing three tablespoonsful in one cup of water with one bushel of soil. Cover the soil with wet burlap or newspapers for 48 hours, remove and plant when the fumes have escaped.

Chloropicrin (trichloronitromethane, tear gas, Larvacide, Picfume), a heavy liquid, is highly effective against nematodes, weed seeds, soil insects and soil fungi. It must be applied with special soil injection equipment and the soil sealed with moist soil, wet papers, or burlap for 48 hours. Normal dosage is 300 to 400 pounds per acre. A 14 day waiting period is necessary.

Ethylene dibromide (EDB, Dowfume W85, Soilfume 85), a colorless volatile liquid, is effective only against nematodes and soil insects. It is well adapted for large field or greenhouse use. Apply it four inches under the soil with special tractor mounted equipment. Use four and one-half gallons per acre on upland and six gallons per acre on muck soils. Ethylene dibromide should not be used where onions will be grown within three years.

Dichloropropene—dichloropropane mixture (D-D), a black volatile liquid, is effective only against nematodes and soil insects. It is well adapted for large field or greenhouse use. Apply it four inches under the soil like EDB. Use 20 gallons per acre on upland and 40 gallons per acre on muck soils.

Dichloropropenes mixture (Tel-one) has the same properties and uses as D-D except that the dosage rate is only 16 gallons per acre on upland and 32 gallons per acre on muck.

Dichloropropenes 75 percent plus ethylene dibromide 19 percent (Dorlone), a volatile liquid mixture of Telone and EDB, widens the effectiveness against, vari-

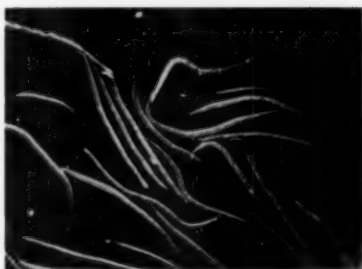


Figure 43. Onion bulb nematode (bloat)
Ditylenchus dipsaci ($\times 40$)

ous nematode species. It does not affect weed seeds or soil fungi. Apply it to soil in the same manner as D-D or Telone, but at a reduced dosage of 12 gallons per acre. It should not be used where onions will be grown within three years.

Sodium methyldithiocarbamate (Vapam, VPM) is a new purple liquid to be mixed with water and applied with a sprinkling can, hose proportioner, sprayer, or irrigation system. It requires abundant water for good dispersion. It is a multipurpose chemical good against all soil pests including weeds, nematodes, and diseases. It can be applied broadcast or in marked rows. The usual rate is one quart in 15 to 20 gallons of water per 100 square feet. It requires a 14 to 21 day waiting period with the soil crust being broken after seven days.

Bedrench is a mixture of allyl alcohol (81 percent) and EDB (11.5 percent). Bedrench is mixed with water and applied like Vapam or VPM. It is especially effective for nematodes and weed seeds and has some effect on soil fungi. Considerable water and a 14 day waiting period are needed.

Preparation and procedures for soil fumigation with liquids

For best results from fumigation, the soil should have been plowed and fitted as for planting. It should be at least 55°F. at the four-inch level and be moist enough for good seed germination. All clods and old plant



Figure 44. Tractor mounted pressure fumigation rig. Note drop-pipes behind each shoe. (Courtesy Dow Chemical Co.)

parts should be broken up. Fall is the ideal time for fumigation; crops have been harvested but temperatures are still moderate. Spring treatments generally necessitate considerable delay in planting dates. All fumigants, except methyl bromide, require a lapse of time of at least 14 and preferably 21 days between treatment and planting. Do not try to reduce this time. For large field applications, tractor mounted equipment is the only feasible method. Pressure or gravity kits will deliver the liquid just behind each cultivator shoe or chisel. The gravity rigs merely drop the chemical into the plow sole.

The home gardener can buy EDB 40 or D-D and make the application from a quart fruit jar with two eight-penny nail holes punched in the lid. With a hoe, make furrows six inches deep and ten inches apart across the garden. Pour a single stream of undiluted chemical along the trench. Use approximately one cup of D-D or one-half cup of EDB 40 for each 75 feet of row. Immediate covering and tamping should be done to seal the gas in the soil. Continue these ten-inch spacings across the garden.

For further information on soil fumigation, contact your county agricultural agent.

Gas under pressure

Methyl bromide (MC₂, Pestmaster SF-1, Bedfume) is a gas in pressure cans or cylinders. It must be applied with a special kit under a plastic cover. For nematodes, soil insects, and weed seeds only one pound per 100 square feet is required. To kill soil fungi in addition to these pests, three pounds should be used. The gas is very penetrating and efficient and also has the advantage of requiring only a 48 hour wait between treating and planting. It is not practical for large field application, but is good in greenhouses, coldframes, and outdoor seedbeds.

Wettable powders or dusts

Pentachloronitrobenzene (Terraclor) is a yellowish white wettable powder or dust. Various application methods may be used including suspension in transplant water, soil surface sprays or dusts, and dry incorporation in the upper four inches of soil. It is effective only against certain fungus species and not against nematodes, insects, or weed seeds. Its greatest activity is toward *Plasmodiophora*, *Rhizoctonia*, *Sclerotinia*, *Sclerotium*, *Streptomyces*, *Tilletia*, and *Botrytis*.

Captan (Orthocide, captan) is a complex organic yellow wettable powder or dust. Its only use is as a fungicide, with no effectiveness against other pests. In addition to its extreme usefulness and safety as a foliage fungicide and seed treatment material, it has found profitable usage as a soil drench in tomato, pepper, and eggplant seedbeds and, when mixed with Terraclor, in cabbage, cauliflower, and lettuce seedbeds.

Mytone (Soil Fumigant M) is a complex organic white powder with multipurpose activity against all soil pests including weeds. It is always used as a pre-plant treatment with a 21 day waiting period. Mytone is

formulated as an 85 percent wettable powder and as a dry mix with a bran carrier. The former is applied at a rate of one-half to three-fourths pound per 100 square feet with 20 to 25 gallons of water and the dry 50 percent mixture at $1\frac{1}{3}$ pounds per 100 square feet with a fertilizer spreader. This is then watered in with 20 gallons of water or $\frac{1}{2}$ inch of rain or irrigation water.

Nemagon and Fumazone are new chemicals formulated as liquids or absorbed on inert powders. They are effective only against nematodes. They are very slow acting and can be used safely adjacent to certain living plants. The liquid may be injected in the soil or the powder may be applied like fertilizer and then incorporated with the soil. Recommended for trial use only, until further testing is done.

Mercuric chloride (bichloride of mercury, corrosive sublimate) is an old chemical soil drench useful on crucifer seedbeds for *Rhizoctonia* control. One ounce is dissolved in a little hot water and then diluted to 15 gallons. One pint is applied to each square foot of seedbed after planting. After emergence, the base of the plants may be treated with a stream of the solution using one pint for each four feet of row.

For clubroot control on cabbage and Brussels sprouts transplants 3 ounces in 50 gallons of water is applied at the rate of $\frac{1}{3}$ of a pint per plant.

Calomel (Calogreen, mercurous chloride) is expensive and is used in transplant water for clubroot control on broccoli and cauliflower. 8 ounces in 50 gallons of transplant water is applied at the rate of $\frac{1}{3}$ pint per plant. Terraclor is rapidly replacing it for this purpose.

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Ithaca, New York



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